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Biostatistical Research on *Rattus losea* (SWINHOE, 1870), a Formosan Wild Rat, with Special Reference to its Diagnostic Characters for Taxonomy

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Biostatistical Research on *Rattus losea* (SWINHOE, 1870), a Formosan Wild Rat, with Special Reference to its Diagnostic Characters for Taxonomy.

Bunichirô AOKI and Ryô TANAKA

(Accepted for publication, May 16, 1938).

CONTENTS.

I. Introduction.

It is a fact that a quantitative method working with a large series of specimens has lately been made available in the field of taxonomy among students of mammalogy and of other vertebrates.

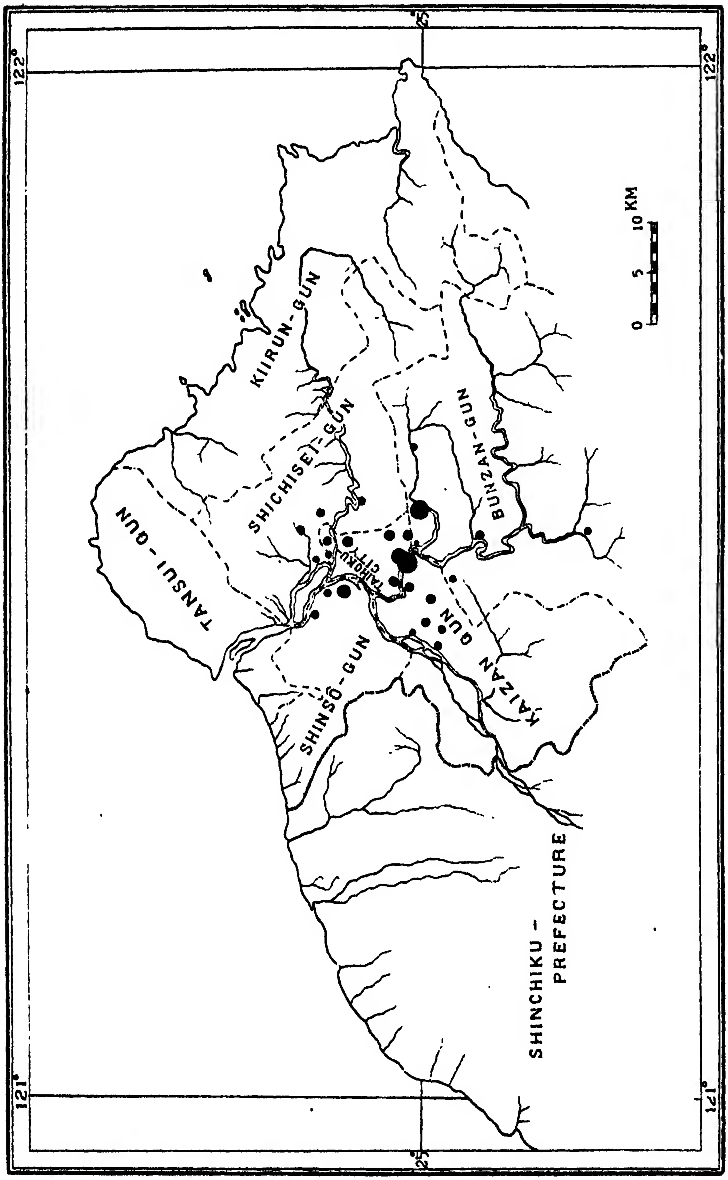


Figure 1.
The map of the northern part of Formosa, showing approximately the relative amount of specimens collected from every locality by the area of the black dot.

forms, the investigation of the northern specimens is first of all necessary. Having finished this study of the northern forms, we wish to extend our research to the southern forms and make a general geographical and distributional study of the whole forms in this island.

III. Methods.

In the preparation of the skins for study, the customary method of furnishing a temporary stuffing specimen was employed. The taking of the external measurements in the flesh and the preparation of the stuffing specimen were accomplished by three trained collectors belonging to our institute, except for the number of the scale rings of the tail. The external measurements were made with a divider and read to the nearest millimeter.

(a) *Head and body length.* This is the distance from the tip of the snout to the center of the anus. In taking this measurement the body is laid on its back on the board and stretched slightly so as to be held in the natural position. This often is called merely *Body length.*

(b) *Tail length.* The distance from the center of the anus to the tip of the tail, exclusive of terminal hairs.

(c) *Hind foot length.* In most cases the right foot was given, measured from the heel end to the tip of the middle digit (exclusive of the claw).

(d) *Ear length.* The measurement is taken from the bottom of the notch immediately behind the tragus to the most distant point of the tip. The right ear in most cases was selected.

(e) *Number of scale rings in one centimeter of tail.* On the dorsal side and nearly at the middle part of the tail, the number of scale rings included within the length of one centimeter was calculated by the author before the animal was stuffed.

(f) *Body weight* was taken with a common balance and recorded in grammes.

The skull specimen was prepared by the same collectors and the cranial measurements were all made by the author himself with a vernier caliper reading to tenths of millimeter. In the case of paired measurements only the right side was taken, except in cases of injury to this and in the length of the incisive foraman. The nomenclatures

of the cranial measurements are principally in accordance with those designated by THOMAS ('05).

With regard the method of exhibiting coloration and shade of the pelage and other parts of the specimen, we have mostly adopted RIDGWAY's color nomenclature (RIDGWAY 1886, nec 1912). All capitalized color terms, therefore, refer to his designation.

IV. External qualitative characters.

(1) *Pelage.*

The adult pelage on the dorsal surface generally consists of three kinds of hairs. Very abundant and fine, slightly undulated hairs which constitute the greater part of the underfur as is the case in those of many other rodents, are basally of a slate color, with a subterminal band of Ochraceous or Ochraceous Buff and a black tip. The general coloration of the dorsum is extensively dependent upon the shade of their subterminal bands. The overhair is made of two kinds of longer and coarser hair without any ochraceous band. One of them is a spine, basally of a dilute slate, the distal region being black, while the other is longer but finer than the former and of a black color, fading slightly toward the base. The black parts of the overhair may largely affect the dark hue of the fur. The longest black hair is of the smallest quantity among the three hairs, distributed scarcely on the head and flank, progressively increasing posteriorly toward the lumber, where the largest amount is found.

On the ventral surface, the overhair is composed of only one type of hair, probably corresponding to the dorsal spine, which is of a white or very dilute color throughout its length, and the hair of the underfur is slate in color, with a white or very slightly colored tip.

The hand and feet are clothed with dirty whitish, short hairs, except for the palm and sole.

The tail hair arranged in threes on every scale is very similar

to the scale in color, so as to be invisible to the naked eye, and approximately once or twice as long as the scale, apart from somewhat longer tip hairs.

It has been found that in general the adult has longer and coarser pelage with more developed spines than in the young, and that the winter rat tends to be provided with a longer and softer pelage with less developed spines than that of the summer form. Details in these respects will be described elsewhere.

(2) *Coloration.*

It appears most reasonable to begin by dealing with the color of a certain normal adult individual of this rat and then extend our description to the general age and individual variation, in order to obtain sufficient notion of the veritable status of the character and the range of its variations.

Color of an individual (Coll. No. 3705, female, Jul. 1937):—The dorsal side of the pelage may be dark Ochraceous in general appearance, being washed with Ochraceous and darkened by a uniform sprinkling of black-tipped hairs, fading gradually to dark Buff or Wood Brown toward face, cheek, flanks and rump, while to a slight degree growing darker toward the lumber owing to the developed long, black hairs. The gray color of the ventral surface may be near to Gray 10, suffused faintly with Primose Yellow as a whole, but rather noticeably tinged in the median part of the lumber and inguinal regions. The chest just in front of and between the fore legs is sparsely washed with light Buff. The contrast between the flank and ventral colors is somewhat conspicuous, but the line of demarcation might not be distinct, though rather straightly defined.

The feet and hands are grossly dull white, except the palm and sole, while there is an indefinite longitudinal stripe of dark Olive on the back, which is relatively wider on the hands than on the feet, though about the same in actual width. As to the hand stripe, however, it might well be said that the hand is bordered with white-colored hairs, as described in SWINHOE's original paper (SWINHOE 1870).

The tail shows a tinge of Mouse Gray with an obscure silvery lustre both on the upper and under side, in other words it is quite unicolored, even if the proximal portion of the under side is inclined to be scarcely lighter. The annulations may be rather pronounced, because they are marked with dull white along their distal edges.

Age and individual variations in coloration: The whole series of the present specimens are largely subject to color variations due to diverse kinds of causes, among which age and individual differences doubtless play an appreciable part in their production. In investigating these variations, the several important characters most likely to undergo a marked variation, have been chosen as the chief objects of our observations. They comprise the general dorsal color, the ventral gray tinge and its suffused yellowish tint, the distinctness of the line of demarcation, the tail color and the grade of its bicoloredness, and the status of the dark stripe of the hind foot, which have been observed and described for every individual and the descriptions rearranged according to the sex difference and the order of the body length of the specimen to obtain the correlation table exhibiting whether or not some relationship exists between color shade and body length.

As will be seen in table 1, the general dorsal color of the juvenile specimen tends to be more extensively of a dark shade, such a Hair Brown, Olive or Wood Brown, as compared with that of the larger form, which is mostly washed with relatively lighter shades, dark Ochraceous and dark Ochraceous Buff including yellow ochre instead of sepia.

The transitional stage from the dark juvenile color to the adult light one occurs, it should be pointed out, at 120-130 mm. of body length in the male and 120 mm. in the female, when the relative number of specimens exhibiting both color phases is made about equal.

Even among larger specimens beyond the transitional size, the junior forms show still more than a little Wood Brown and Hair Brown, and relatively more frequently dark Ochraceous Buff than do

TABLE 1.
Correlation between general dorsal color (C) and head and body length (HB).

	C \ HB (mm.)	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	Σ
Female	Σ		2	6	14	14	18	28	56	59	67	50	16	1		331
	Cinnamon, Russet						1		2	1	0,5			1		5,5
	dark Cinnamon, dark Russet									0,5	0,5	1				2
	dark Ochraceous							3	17	30,5	43	40	13			146,5
	very dark Ochraceous			0,5			1		4,5	10,5	9	3	1			29,5
	dark Ochraceous Buff		1,5	2		0,5	2	2	9,5	6	4,5	2				30
	very dark Ochraceous Buff							3,5	12	5	6	1,5				28
	dark Buff															0
	very dark Buff								0,5							0,5
	Wood Brown		0,5			0,5										1
	dark Wood Brown			0,5	2	1	1	5,5	3	3	3,5	2				21,5
	very dark Wood Brown															0
	Hair Brown, Olive			3	12	12	13	14	7,5	2,5		0,5	2			66,5
Male	Σ		4	2	11	9	16	33	41	43	56	91	69	20	3	398
	Cinnamon, Russet									1,5	1,5	2,5	3	0,5		9
	dark Cinnamon, dark Russet								0,5				0,5			1
	dark Ochraceous						0,5	3,5	8,5	18	35,5	76,5	59,5	17,5	3	222,5
	very dark Ochraceous								1	4	2	2	1	2		12
	dark Ochraceous Buff		1			0,5		6,5	7	7,5	11	6,5	2,5			42,5
	very dark Ochraceous Buff			1			1		5,5	6	4	1	2			20,5
	dark Buff								1			0,5				1,5
	very dark Buff							0,5								0,5
	Wood Brown		1			1										2
	dark Wood Brown		1			0,5		5	8	3	2	2	0,5			22
	very dark Wood Brown								0,5							0,5
	Hair Brown, Olive		1	1	11	7	14,5	17,5	9	3						64

the larger ones of both sexes. Such a smaller form might be regarded as a subadult.

In any case the dorsal surface of the larger specimen as a whole is to be tinged for the most part with a dark Ochraceous, occasionally with dark Ochraceous Buff, rarely with dark Buff, Cinnamon or Russet and Wood Brown or Hair Brown. The mode of the frequency

of the dark Ochraceous group for the male falls into the class 151-160 mm. of body length, while that for the female 141-150 mm..

The ventral side is washed with an underlying gray color on the whole, over which a yellowish or whitish tinge is to a greater or lesser degree additionally suffused. The relation between the gray shade and the body length is given in table 2.

TABLE 2.

Correlation between gray shade of ventral side (C) and head and body length (HB).

	C \ HB (mm.)	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	141-150	151-160	161-170	171-180	181-190	Σ
Female	Σ		2	6	14	14	17	29	54	56	62	46	14	1		315
	whitish												1			1
	Gray 10			1							4	0,5	0,5			6
	Gray 9					1	1	4	21	33	45	36,5	9,5	1		152
	Gray 8		1	1	1,5	3	11	19	27	16	9	9	3			100,5
	Gray 7		1	2	7,5	8	5	6	6	6	4					45,5
	Gray 6			2	5	2				1						10
Male	Σ	1	4	1	11	9	14	33	39	42	55	90	68	20	3	390
	whitish		1						1							2
	Gray 10	1							1,5	0,5	3	5,5	0,5			12
	Gray 9							7	15,5	23,5	35	66,5	58,5	15	3	224
	Gray 8		3	1	3	3	3,5	12	14	15	15	14	6	4		93,5
	Gray 7				7	4,5	8	11	5	3	2	4	3	1		48,5
	Gray 6				1	1,5	2,5	3	2							10

It is seen from this table that along with an increase in the size of the specimen, the gray shade becomes paler and paler, never indicating any distinct transitional phase, despite the fact that some extremely juvenile forms (50-80 mm. body length) show the reverse tendency particularly in the male. The special inclination toward lightening in the smallest forms should be noted, together with the alike minute tendency in the dorsal color, because it would seem to suggest a feature of the most juvenile pelage.

TABLE 3.
Correlation between yellowish and whitish tinge of ventral side (C) and head and body length (HB).

	C \ HB (mm.)	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	Σ
Female	Σ		2	6	14	14	16	29	54	57	61	47	14	1		315
	* yellowish tinge absent or nearly absent		2	3	13	10	11	8	4	3	3	5	2			64
	Buff					1							1			2
	whitish Cream Buff				1	1										2
	pale Cream Buff										1	3	1			5
	Cream Color			1			1	1		3,5	4	3	1	0,5		15
	pale Cream Color			2				5	6	6	10	5	3			37
	whitish Cream Color					1	2	5	6	10	15	9	2			50
	very whitish Cream Color							1	3	3	1					8
	Straw Yellow									7	1	2				10
	whitish Straw Yellow															0
	Primose Yellow							1	7	9,5	4	7	1	0,5		30
	pale Primose Yellow								4	1	3	2				10
	whitish Primose Yellow					1		6	14	8	14	6	3			52
	very whitish Primose Yellow						2	2	10	6	5	5				30
Male	Σ	1	4	1	11	9	14	33	38	44	55	90	67	19	3	389
	* yellowish tinge absent or nearly absent		4		10	6	12	14	10	4	5	2	6			73
	Buff								1							1
	whitish Cream Buff									1				1		2
	pale Cream Buff				1				2			1				4
	Cream Color										1	3	2			6
	pale Cream Color			1				3		1	4	11	4,5	1		25,5
	whitish Cream Color						1	4	3	9	8	18	13	5		61
	very whitish Cream Color									1	1	6	4			13
	Straw Yellow							2,5	3	2	2	2,5	0,5	2		14,5
	whitish Straw Yellow										1					1
	Primose Yellow					1	1	6,5	8	4,5	12	10	10	8	1	62
	pale Primose Yellow								1	2	3	2				8
	whitish Primose Yellow					2		1	7	10,5	12	23,5	18	1	1	76
	very whitish Primose Yellow							2	3	9	6	11	9	1	1	42

* including cases of whitish only.

According to table 3, the specimen without any overlaid yellowish tinge or with some whitish tint alone on the ventral surface is

apparently found to relatively increase toward the smaller body length. The ventral side of the larger form may be in general washed most frequently with pale Cream Color or Primose Yellow, with in many cases a whitish shade added, rarely with Straw Yellow, Cream Buff or Buff or a whitish tinge only in both sexes, showing no color change with increasing body size. The change from the juvenile to the adult status have been assumed to occur at a size of 110-120 mm. body length in the male, while about 110 mm. in the female, at which point the number of specimens devoid of a yellowish tinge approximately amounts to a half of the total examined in the class.

The above described yellowish or whitish tinge is diffusedly or sporadically suffused over the whole ventral surface, but in addition there may be occasionally developed a relatively deeper shade than the diffused color in the inguinal region or in the median line, which is shown by Cream Color, Straw Yellow, Cream Buff, Primose Yellow or Buff, either bright or pale or whitish.

No marked sexual color dimorphism except the discrepancy brought out from the difference of body length are perceptible either on the dorsal or on the ventral side.

TABLE 4.

Correlation between distinctness of demarcation line (D) and head and body length (HB).

	D \ HB (mm.)	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	131-140	141-150	151-160	161-170	171-180	181-190	Σ
Female	Σ		2	6	14	14	18	27	55	58	65	47	15	1		322
	I . .							3	3	5	6	2	2			21
	II . .					1	1	1	3	8	6	7		1		28
	III . .		2	1	2	2	4	9	21	28	35	21	8			133
	IV . .			5	12	11	13	14	28	17	18	17	5			140
Male	Σ	1	3	2	11	8	14	32	38	44	54	88	68	20	3	386
	I . .							2	4	1	5	3	5	1		21
	II . .					1	1	3	1	3	7	7	6	5	1	35
	III . .			1	1		1	5	20	17	22	48	35	10	2	162
	IV . .	1	3	1	10	7	12	22	13	23	20	30	22	4		168

I→IV; arranged so as to become more distinct.

The line of demarcation of the pelage may be not well pronounced upon general inspection, and appears to undergo to some extent·age and individual variations. The arbitrary scale of the grade in the distinctness of this line is correlated with the body length as shown in table 4. From this table, it can be seen that the line of demarcation becomes gradually indistinct with increasing body length, however diminutive the change may be, and that variations bearing on this character, due to age as well as to individual difference, take place only to a small extent.

The color of the tail and the situation of the color differentiation above and below were examined and also they change together with advancing age and individual difference. As will be shown in table 5, the dorsal tinge of the tail is prevalently Mouse Gray or Slate

TABLE 5.

Correlation between above shade of tail (S) and head and body length (HB).

	S \ HB (mm.)	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	Σ
Female	Σ		2	6	14	14	17	29	54	58	63	43	13			313
	* silvery lustre . . .								2	7	2	4	2			17
	Drab Gray				1		1	2	2,5	1	3	4	2			16,5
	Smoke Gray							1	1	6	7	7	2			24
	Olive Gray								1		1	2				4
	Mouse Gray			3	6	4	10	13	25,5	37	45	22	7			172,5
	Slate Gray		2	2	2	8	4	7	19	10	·6	6	1			67
	Slate Color			1	5	1	1	5	5	4	1	2	1			26
	Slate Black					1	1	1								3
Male	Σ	1	4	2	11	9	15	33	40	43	50	88	67	17	3	383
	* silvery lustre . . .								1	7	5	12	14	5		44
	Drab Gray							1		2	3	3	5	3		17
	Smoke Gray							1 •		3	5	15	11	5	1	41
	Olive Gray									3	3	8	3	2		19
	Mouse Gray			1	8,5	2	6	17	24	22	88	49	28	5	1	191,5
	Slate Gray	1	4	1		6	8	9	8	11	9	11	19	1	1	89
	Slate Color				2,5	1	1	4	4	1	1	2	1			17,5
	Slate Black							1	4	1	1			1		9

The color term is arranged so as to become successively paler from below to above.
* Figures in this paragraph were not comprised in the total.

Gray throughout the whole range of the body length. However, generally speaking, the darker shade may be relatively more frequent in the juvenile stage, while in the adult the lighter shade increases, though the gradation from dark to light is but small.

The intermediate zone between the opposite phases would be supposed to take place at about 120–130 mm. body length in both sexes. The individual difference between the adult specimens in the above color of the tail ranges from Olive Gray or Drab Gray to such a dark shade as Slate Black, among these Mouse Gray and Slate Gray form the majority, followed by Smoke Gray and Slate Color, occasionally with silvery lustre added.

The below tinge of the tail may likewise be subject to the similar variations within a slightly narrow range and therefore the diverse kinds of the grade in bicoloredness will be given. Whether or not any correlation between the grade of bicoloredness and body length may exist will be seen from table 6.

TABLE 6.

Correlation between grade of bicoloredness of tail (B) and head and body length (HB).

	B / HB (mm.)	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	Σ
Female	Σ		2	6	14	14	17	29	54	58	63	43	13			313
	scarcely bicolored			1		2	1	4	11	11	24	17	3			74
	moderately bicolored			3	8	7	13	21	29	38	33	22	9			183
	markedly bicolored		2	2	6	5	3	4	14	9	6	4	1			56
Male	Σ	1	3	2	11	9	15	33	40	43	52	88	67	17	3	384
	scarcely bicolored	1						4	7	11	20	36	35	9	3	126
	moderately bicolored			1	8	5	11	22	26	26	27	46	28	7		207
	markedly bicolored		3	1	3	4	4	7	7	6	5	6	4	1		51

According to the relative grade of bicoloredness of the tail, the specimens were arbitrarily separated into three groups, scarcely, moderately and markedly bicolored. It should be remembered that, as a whole,

the tail of this species may be regarded as rather indistinctly bicolored.

This table shows that the bicoloredness continues to be reduced along with increasing body length until ultimately the scarcely bicolored specimens are found most frequently in the males, while it does not go so far in the female in which the tail is inclined to be more often moderately bicolored even in the largest specimens.

In the adult, therefore, the tail may be considered as generally rather bicolored, more often including the unicolored status in the male. The intermediate stage between the juvenile markedly bicolored state and the adult obscurely bicolored seems to occur at nearly 120–130 mm. body length in both sexes.

The dark stripe on the back surface of the hind feet appears to undergo as many different variations as any other characters do. Because its variation may be extensively paralleled with that of the hand, only the former, especially with reference to its distinctness has been mainly examined throughout the series of specimens. The correlation between the foot stripe and the body length is shown in table 7.

The arbitrarily determined scales are arranged to be made more conspicuous and darker successively from I to VII. Accordingly, we can see from this table that though the stripe is subject to a considerably wide range of individual variation, there can be little doubt that some age variations take place, that is to say, the stripe shows a tendency to fade gradually with advancing age. The transition from the juvenile more distinct status to the adult paler one looks as if it occurred at 110-130 mm. body size in the male, while at 110–120 mm. in the female.

A race of *Peromyscus* has been described by COLLINS ('23) as assuming three distinct pelage phases in the postnatal development, namely, the juvenile, the postjuvenile and the adult, and to become progressively lighter in the shade of the pelage with advancing age, mainly owing to the large increase in the percentage of orange-yellow.

As to the present specimen, by virtue of the foregoing observations we may only be led to infer the apparent presence of juvenile

TABLE 7.

Correlation between distinctness of stripe in hind foot (S) and head and body length (HB).

	S \ HB (mm.)	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151–160	161–170	171–180	181–190	Σ
Female	Σ		2	6	14	14	17	28	54	58	67	48	16	1		325
	I . . .				3		1	3	12	12	12,5	10	4			57,5
	II . . .					2	4	6	23	26	26,5	17	6	1		111,5
	III . . .				1		1	5	2	7	11	5	1			33
	IV . . .			1	2	2		5	5	6	5	6	2			34
	V . . .				6	3	4	3	8	5	8	6	2			45
	VI . . .		1	3	2	7	6	6	2	2	4	2	1			36
	VII . . .		1	2			1		2			2				8
Male	Σ	2	4	2	11	9	16	34	41	43	53	92	72	19	3	401
	I . . .						1	5	6	5	12	10	5	4		48
	II . . .					1	2	4	11	16	11	33	20	6	1	105
	III . . .					1	2	6	6	6	5	13	10	2		51
	IV . . .				3	2	2	2	6	5	6	11,5	15,5	2		55
	V . . .				3	2	5	9	4	7.5	11	15,5	13,5	3	2	75,5
	VI . . .	2	4	1	2	2	3	7	7	3,5	8	9	8	2		58,5
	VII . . .			1	3	1	1	1	1							8

I→VII; arranged so as to become progressively more distinct and darker.

and adult pelage phases provided with distinguishable color trends, respectively dark and light. We will however be able to perceive that a transitional and intermediate phases may exist between these two opposite series of pelages. It may be conjectured that the post-juvenile and subadult phases are located in the neighbourhood of this transitional zone.

Here, we should notice the fact that several extremely juvenile forms show relatively lighter shades despite general dark trends in the pelage color.

It is regretted that it is still uncertain to what degree the above

designated phases in this rat may correspond with the precise ones shown by COLLINS in the deer mice. At any rate we have eventually been led to discern three phases, namely, the juvenile, the adult and the transitional, which are based on evidences concerning with not only the pelage colors, but also the dorsal shade of the tail and its bicoloredness, and the stripe of the hind food. From these evidences, the transitional phase may be summed up as occurring approximately at the time of the following body length:

	Male	Female
General dorsal color of the pelage	120–130 mm.	120 mm.
Yellowish and whitish tinge of the belly	110–120 mm.	110 mm.
Dorsal shade of the tail	120–130 mm.	120–130 mm.
Bicoloredness of the tail	120-130 mm.	120–130 mm.
Stripe of the hind foot	110–130 mm.	110–120 mm.
Mean	.........122 mm.	119 mm.

Hence, taking the mean, it occurs at about 120 mm. body length within a range of 110-130 mm., the male preceding slightly the female in size.

It is usually known that the younger rat and mice, as a rule have a tendency to be somewhat darker and duller in the pelage shade as compared with the adult, for instance it is pointed out in the meadow mice by HOWELL ('24), in many British murine forms by BARRETT-HAMILTON ('16) and in others. Such a general feature has been emphasized with some degree of certainty by the present material as well in deer mice by COLLINS.

It is also reported by HOWELL ('24) that in the meadow mice, the pelage shade of the male is relatively more uniform than that of the female. Notwithstanding, the present rat, so far as our examination has gone, appears not to show any sexual difference in the color variation. But it is only recognisable that the specimen with the unicolored tail is found to be more prevalent in the larger male as compared to the female.

(3) *Mammae and plantar tubercles.*

The female is possessed of ten mammae, comprising two pectoral

and three inguinal pairs. The juvenile specimen is inclined to be devoid of the full complement and the well-developed status which can be seen in the majority of the larger specimens. Throughout the whole series of the material, the first pectoral and the last inguinal pairs were those most often failing to be pointed out, which may be supposed to be on one hand due to the natural situation, on the other hand to have followed from the artificial causes in the specimen itself.

There are five plantar tubercles on the palm and six on the sole. They appear to be as relatively invarable as any of the other external characters above quoted. Among them, the postero-lateral on the sole is the smallest in size and the most variable in tendency. The same is the case with meadow mice (HOWELL '24).

V. Relative growth in external measurements.

It was ealier maintained and highly emphasized of late following the mathematical treatment by HUXLEY ('31, '32) and by TEISSIER ('34) that the study of relative growth contribütes greatly to the scientific foundation of taxonomy as well as to other branches of biology, because knowledge of the mechanism of modifications in proportion of measurements with an increasing standard size would be rather preferable for the taxonomists than that of mere changes in absolute length.

The HUXLEY's formula of simple allometry, equivalent to the precedent term heterogony (HUXLEY and TEISSIER '36) may be an excellent and convenient equation exactly representing a direct relationship between the relative size and the standard or whole absolute size of measurements. The application of the elementary law is now being carried out extensively in many branches of biology, using a wide range of materials, regardless of some critical objections (RICHARD '35). Nevertheless, insects and crustaceans have been used in the main as the favourite material for the study of relative growth, while mammals have been so far less used.

In the present paper, we have tried to analyze all the data regarding measurement conforming to the simple allometry law, as expressed by the formula

$$y=bx^{a},$$

wherein x represents head and body length, y other measurments, a and b constants, respectively called equilibrium coefficient and initial growth index (HUXLEY and TEISSIER). The arrangement of the classes for the purpose of computation is made on the basis of the head and body length, the class interval being 5 mm. in all cases excepting several earlier classes with 10 mm. range, because this measurement was taken as the standard size of relative growth. The mean values of measurements by classes and the number of cases participating in the calculation will be shown in table 8.

TABLE 8.

Mean value of external measurement and body weight in each class.

Sex	Class and class range (in mm.)	Number of cases	Head and body length (in mm.)	Tail length (in mm.)	Hind foot length (in mm.)	Ear length (in mm.)	Number of cases	Head and body length (in mm.)	Number of scale rings in cm. of tail	Number of cases	Head and body length (in mm.)	Body weight (in gr.)
Male	(1) 55,5- 65,5	5	61,2	53,6	17.0	10,8						
	(2) 65,5- 75,5	4	69,5	63,3	20,3	12,8						
	(3) 75,5- 85,5	7	82,4	86,4	23,3	15,4						
	(4) 85,5- 95,5	9	90,3	92,6	23,9	16,0				2	91,5	21,5
	(5) 95,5-100,5	6	98,7	98,2	24,8	17,5	1	98	17	2	99,0	32,0
	(6) 100,5-105,5	7	103,7	102,0	26,0	16,4	1	102	16	2	103,0	27,0
	(7) 105,5-110,5	11	108,1	106,6	25,6	18,2	2	108,0	15,5	4	108,0	34,8
	(8) 110,5-115,5	13	113,0	109,0	26,6	17,7	2	112,5	17,0	5	113,2	35,4
	(9) 115,5-120,5	21	118,2	121,2	27,8	17,9	6	118,5	14,0	11	118,3	47,8
	(10) 120,5-125,5	20	123,2	125,8	27,8	18,4	4	123,0	14,8	8	123,1	47,9
	(11) 125,5-130,5	21	127,4	124,8	28,3	18,6	6	127,8	13,5	12	127,8	52,1
	(12) 130,5-135,5	23	133,6	131,8	28,7	18,3	3	133,3	13,3	14	133,3	64,9
	(13) 135,5-140,5	22	138.2	136,8	29,4	19,2	8	138,8	12,3	16	138,2	70,6
	(14) 140,5-145,5	25	142,8	136,9	29,6	19,3	2	141,5	12,0	9	142,8	81,4
	(15) 145,5-150,5	37	148,1	144,2	30,3	19,1	5	147,6	12,8	19	148,4	85,9
	(16) 150,5-155,5	47	153,0	146,4	30,4	19,2	8	152,4	11,9	29	153,1	91,2
	(17) 155,5-160,5	51	157,8	150,2	30,7	19,5	4	157,3	11,5	35	157,8	101,3
	(18) 160,5-165,5	40	163,3	152,4	30,5	19,4	6	164,0	11,3	26	163,3	105,5
	(19) 165,5-170,5	36	167,8	153,2	31,1	19,7	5	169,2	11,2	20	168,3	109,2
	(20) 170,5-175,5	12	172,9	159,7	31,1	20,3	0	—	—	9	173,0	112,1
	(21) 175,5-180,5	9	178,6	157,4	30,6	19,7	0	—	—	3	178,7	114,3
	(22) 180,5-190,5	3	186,0	168,0	31,0	20,3	1	182	11			

Sex	Class and class range (in mm.)	Number of cases	Head and body length (in mm.)	Tail length (in mm.)	Hind foot length (in mm.)	Ear length (in mm.)	Number of cases	Head and body length (in mm.)	Number of scale rings in cm. of tail	Number of cases	Head and body length (in mm.)	Body weight (in gr.)
Female	(1) 60,5– 70,5	3	65,7	63,3	19,7	11,7						
	(2) 70,5– 80,5	7	74,6	72,3	21,0	14,4						
	(3) 80,5– 85,5	8	83,3	82,0	22,4	16,1				5	83,6	25,7
	(4) 85,5– 90,5	6	89,0	89,2	23,8	15,5				2	89,0	19,0
	(5) 90.5– 95,5	6	93,3	89,6	24,4	15,5				2	94,0	22,5
	(6) 95,5–105,5	12	99,3	102.0	25,4	16,8	2	97,5	16,0	5	98,4	32,4
	(7) 105,5–110,5	19	108,0	110,1	26,1	17,2	3	108,3	17,0	8	108,4	34,9
	(8) 110,5–115,5	16	113,0	116,6	26,6	18,0	2	114,0	16,0	6	113,0	45,9
	(9) 115,5–120,5	14	118,1	120,5	26,9	17,8	3	119,0	15,0	9	118,0	37,0
	(10) 120,5–125,5	35	123,1	132.1	28,5	18,3	9	122,7	13,9	23	123,0	56,9
	(11) 125,5–130,5	22	128,1	134,0	28,6	18,3	7	128,9	12,6	·17	128,3	63,1
	(12) 130,5–135,5	24	132,6	138,6	29,1	18,4	8	132,0	13,4	18	132,4	66,0
	(13) 135,5–140,5	39	138,1	145,5	29,1	19,1	4	138,0	12,5	18	138,3	78,3
	(14) 140,5–145,5	39	142,7	150,1	29,5	19,2	5	141,6	12,4	23	142,5	80,7
	(15) 145,5–150,5	34	148,2	151,4	29,3	19,3	7	148,0	11,9	18	148,0	89,4
	(16) 150,5–155,5	31	152,8	152,6	29,0	19,1	4	153,5	11,8	18	152,8	96,0
	(17) 155,5–160,5	24	158,3	156,7	29,3	19,8	4	159,0	11,8	16	158,3	94,4
	(18) 160,5–165,5	10	162,8	164,3	29,9	19,9	2	161,5	10,5	4	161,8	98,3
	(19) 165,5–170,5	*9	*167,6	162,8	29,8	20,2	1	169	11	4	167,5	115,3
	(20) 170,5–175,5	1	171	170	29	21				1	171	99

* Instead of these figures, 5 and 167,8 are given for the case of tail length.

The equation $y=bx^{\alpha}$ may be changed by taking logarithms of both sides into $\log y=\log b+\alpha \log x$. Accordingly the logarithms of the mean values of the measurements by classes plotted against the logarithms of mean values of head and body length must approximate to a straight line when the formula applies to the data (fig. 2).

The theoretical line was determined by means of the method of least squares, but the equilibrium coefficient (α) and the initial growth index (b) as well as their probable errors* were computed from the formulae adopted by GREEN and FEKETE ('35) from SCHMALHAUSEN ('30). The constants are given as follows:

$$\alpha=\frac{\sum n \sum n \log x \log y-\sum n \log x \sum n \log y}{\sum n \sum n \log^2 x-(\sum n \log x)^2}$$

$$\log b=\frac{\sum n \log y \sum n \log^2 x-\sum n \log x \log y \sum n \log x}{\sum n \sum n \log^2 x-(\sum n \log x)^2}$$

* The probable error of log b was computed only for skull measurements.

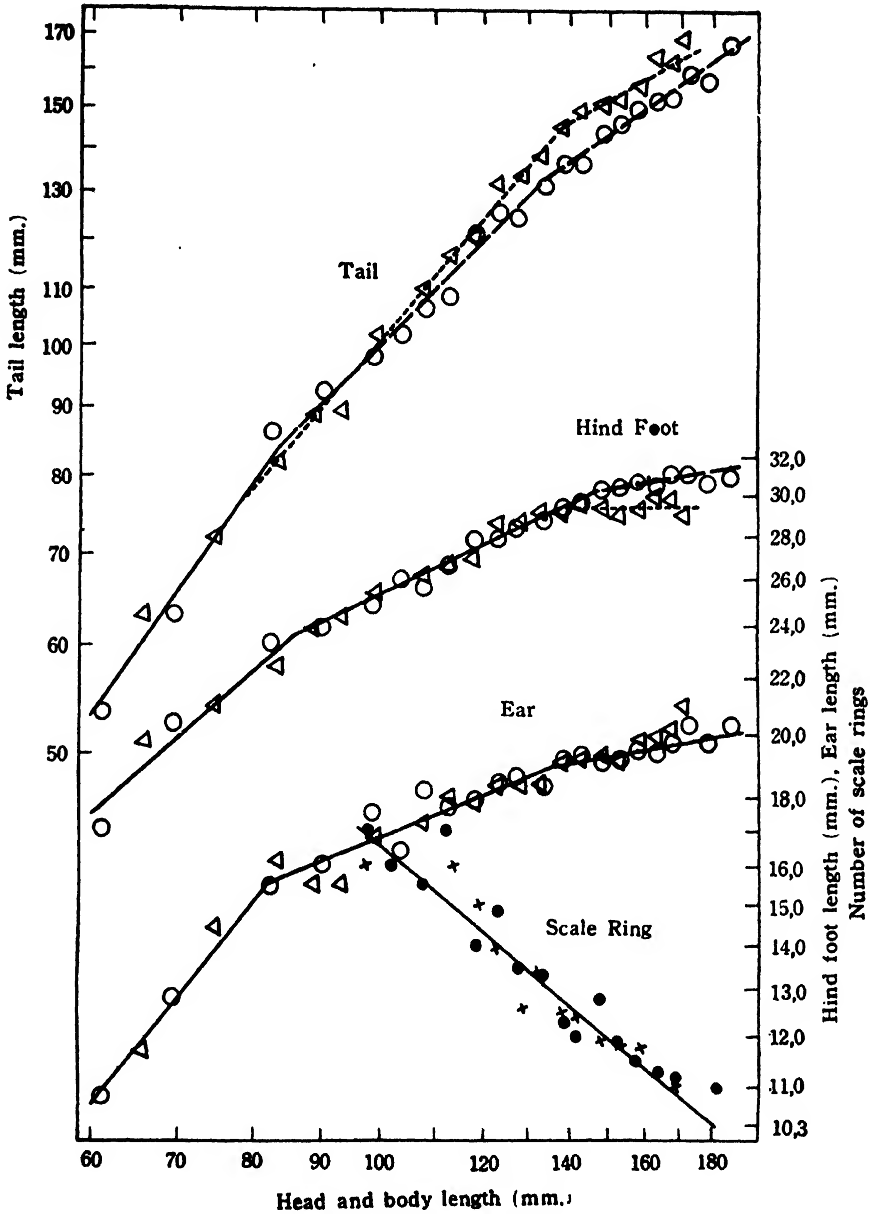


Figure 2.

Logarithmic plot of external measurements (tail length, hind foot length, ear length and number of scale rings in cm. of tail) on head and body length. ○, ●, — — — for males, △, ×, ------ for females, ——— common to both sexes.

In the above formulae, n is the number of individual measurements in each of class based on head and body length, while *log x* and *log y* denote, respectively, the logarithms of the mean head and body length and the other mean measurement in each class. As pointed out by GREEN and FEKETE ('33), the constant obtained by computation with these formulae is more reliable than that obtained merely by the graphic method, though they are less accurate than by the laborious computation from the individual data instead of averages.

The probable errors of these constants are given as follows:

$$\text{P. E.}_{(a)} = \pm 0{,}6745\sqrt{\frac{1}{2}\left(\frac{\sum n}{\sum n \sum n \log^2 x - (\sum n \log x)^2}\right)\left(\frac{\sum n\,\mathrm{D}^2}{\sum n - 2}\right)}$$

$$\text{P. E.}_{(\log b)} = \pm 0{,}6745\sqrt{\frac{1}{2}\left(\frac{\sum n \log^2 x}{\sum n \sum n \log^2 x - (\sum n \log x)^2}\right)\left(\frac{\sum n\,\mathrm{D}^2}{\sum n - 2}\right)}$$

where n is the same as in the foregoing formulae, while *log x* and *log y* reveal respectively the mean of the logarithms of head and body length and other measurement in each class, and D equals the deviation of the theoretical value from the actual value of *log y*, shown by the following formula:

$$\mathrm{D} = \log b + a \log x - \log y$$

The constants with or without their probable errors calculated from the above formulae are presented in table 9.

As will be shown in fig. 2 and table 9, there exist three distinct phases with different growth-constants in tail length, hind foot length and ear length, while the apparent sex difference with regard to distribution of dots on the graph is brought out only in the adult or subadult specimens. It is doubtless to be granted that the dots depart relatively farther from the calculated line in the juvenile and extremely larger specimens with means of more decreased weight in each dot, when compared with those in the adult specimen holding highly weighted means, to which lends the formula a better fit. The average

TABLE 9.

Equilibrium constants (*α*) and initial growth-indexes (*b*) for external measurements.

Measurement		Tail length		Hind foot length		Ear length	
Sex		♂	♀	♂	♀	♂	♀
First phase	α	1,389		0,846		1,223	
	b	0,1804		0,5464		0,7087	
	Calculated class range	*(1)-(3)		(1)-(3)		(1)-(3)	
Second phase	α with p. e.	0,976±0,0121	1,140±0,0049	0,461		0,395	
	Sex difference of α	0,164±0,0130		—		—	
	Diff./p. e.	12,6		—		—	
	b	1,122	0,5316	3,028		2,717	
	Calculated class range	*(4)-(11)	(4)-(13)	(4)-(15)	(4)-(13)	(4)-(13)	
Third phase	α with p. e.	0,677±0,0040	0,547±0,0134	0,161±0,0050	0,0147±0,00513	0,183	
	Sex difference of α	0,130±0,0139		0,146±0,0071		—	
	Diff./p. e.	9,4		20,6		—	
	b	4,815	9,854	13,53	27,23	7,696	
	Calculated class range	*(12)-(22)	(14)-(20)	(16)-(22)	(13)-(20)	(14)-(22)	(14)-(20)
Head and body length at break	1st phase to 2nd phase	83,0 mm.	77,0 mm.	86,0 mm.		82,0 mm.	
	2nd phase to 3rd phase	133,0 mm.	137,0 mm.	147,0 mm.	137,0 mm.	136,0 mm.	

The class number quoted in table 8.

percentage deviations* of the actual from the calculated throughout the entire growth range, were only 1,44–1,81% for both sexes in these measurements.

The numerical test with probable error against the significance of the difference in the magnitude of growth-constants, was made only in relation to the sexual differences in the same phase when the appearance of such tendency was shown on the graph, while with reference to the difference of phases before and after the break it failed to be tried, because the weight of mean, namely the number of cases used in computation of the average, is in the juvenile specimen more diminutive by far than in the adult.

According to HUXLEY, whenever the allometry formula holds good for the growth of the body and its organs, which are considered to be concerned essentially with the multiplication of living substance, it means that the ratio of the relative growth-rate of the organ to the relative growth-rate of the body remains constant, where the relative growth-rate implies the rate of growth per unit size, *i. e.* the actual absolute growth-rate at any instant divided by the actual size at that instant. Thus we have

$$\frac{dy}{dt} \cdot \frac{1}{y} = k \frac{dx}{dt} \cdot \frac{1}{x}$$

where the constant k is equivalent to the equilibrium constant (α).

Strictly speaking, therefore, it can be stated that if the relative growth rate of the part is above or below that of the whole size, the proportionate size of the part increases or decreases with increasing whole size, that is termed positive or negative allometry, while if the relative growth rate of the part is identical with that of the whole size the growth is called isometry, denoting proportion of the part remaining constant.

Tail length.—As to the tail length, the sexual dimorphism concerning the relative growth against head and body length, can be

* averaged from the sum of absolute values of percentage deviation, instead of from algebraic sum.

recognized in the second and third phases, in which significantly different equilibrium constants are given for two sexes. The male constant (0,976±0,0121) is significantly different from the female (1,140±0,0049) in the second phase, for the difference is 0,164±0,0130, or 12,6 times its probable error, while in the third phase the difference is 9,4 times its probable error.

In the first phase, each sex shows positive allometry with α indicating the common value (1,389) up to a body length of 83 mm. for males, and of 77 mm. for female, after which females grow at a more rapid rate, maintaining positive allometry (α, 1,140), than males with α equalling 0,976, in other words, showing nearly isometry. Furthermore the second breaks in relative growth, take place more abruptly especially in females, at respectively 133 mm. for males and 137 mm. for females, followed by negative allometry with the similar value of α for both sexes (0,677 and 0,547) in the last phase.

It can be readily justified from the status of change in the constants, that the male relative tail length against body length increases at the same rate as the female in the first step until the maximum value is reached at 83 mm. body length, and thereafter it keeps nearly constant up to 133 mm. while in the last phase it markedly decreases. As contrasted with males, females continue to increase in relative tail length up to the end (137 mm. body length) of the second phase, in which the maximum is attained for the first time, after which the same change as in the males takes place in the last phase.

In our preliminary papers (AOKI and TANAKA '34, '35), though the theoretical line was drawn by the graphic method, not taking the weighted mean into consideration, approximately the same situation as above described regarding the change in the relative tail length could be concluded by applying the following form of formula;

$$x-y=bx^k$$

wherein x is head and body leneth, y measurements, b and k constants.

From the graphic evidence of the significantly different curve of

relative growth for each sex in fig. 2, the theoretical value of the relative tail length in the female is seen to be always superior to that in the male at a range of approximately 100–180 mm. body length.

Some interesting relations between tail length and body temperature have been brought to light by PRIZBRAM ('25) working on *Rattus norvegicus* and *Rattus rattus.* He maintained that the relative tail length of these rats becomes increased gradually with advancing age, accompanied by rise of the body temperature up to shortly before the time of puberty, when the maximum value in the body temperature as well in the relative tail length may be attained for each sex while the sexual difference on these values is reduced to a minimum.

If the same conclusion may also be applied to the present species, the rat would attain adolescence with the maximum body temperature in the second phase for the male, and at a body length of near 137 mm. for the female, because the maximum relative tail length is assumed at that time.

The relative growth of tail length in *Rattus rattus alexandrinus* and *R. norvegicus* from the data by NEGISHI ('31) is to be understood to indicate positive allometry in the earlier phase, but after the time of the maximum relative tail length has passed the growth is more or less negatively allometric. In these instances as well, of course, the female always exceeds the male in relative tail length.

It is quite inexplicable that notwithstanding these facts, the relative tail length in the albino rat and the Norway rat according to the data of DONALDSON ('24) should increase with body length up to the end indicating no maximum point during the whole period of growth.

The tail length in a certain strain of *Mus musculus*, according to GREEN and FEKETE ('33), reveals relative growth of markedly positive allometry (α, 2,19) against the total length before the break which marks the metamorphosis of the mouse from juvenile to adult proportions, after which, approximately, isometry is shown with α being 1,01. Nevertheless, the data of a mouse, *Phenacomys longicaudus*,

was recalculated by HUXLEY ('32) from TAYLOR ('15) and it was proved that the relative growth of tail length is positively allometric with a being about 1,41 only for the treated range of the data.

The equilibrium coefficient of tail length against body length in the rat and mouse is to be summed up as following:

Species	Sex	First phase	Second phase	Third phase	Author
Rattus losea	♂	1,389	0,976	0,677	AOKI & TANAKA
	♀		1,140	0,547	
R. rattus alexandrinus	♂ ♀	>1	<1		NEGISHI ('31)
R. norvegicus		>1	approximately <1		
R. rattus *R. norvegicus* *R. norvegicus albinus*	♂ ♀	>1	<1 or close to 1		PRIZBRAM ('25)
R. norvegicus albinus *R. norvegicus*	♂ ♀	>1			DONALDSON ('24)
Mus musculus		2,19	1,01		GREEN & FEKETE ('33)
Phenacomys longicaudus		1,41			TAYLOR ('15)

Consequently, it may be generally stated that relative growth in tail length of the house rat and mouse (*Rattus norvegicus*, *R. norvegicus albinus*, *R. rattus* and *Mus musculus*) presents at least two distinct phases, of which the earlier expresses positive allometry while the later negative allometry or isometry. The break in the growth rate may be conjectured to occur approximately at the time of adolescence. As contrasted with them, in *Rattus losea* it can be analyzed into three distinct phases, and the time of the onset of puberty being inferred to take place approximately in or at the end of the second

phase. Hence, we are led to suppose that the later phase in the house rats would be comparable with the third phase in *R. losea*, and therefore the earlier phase in the former might be presumably divided into two phases, if a strict mathematical treatment is applied to it.

It is remarkable that the value of the coefficient for *Mus musculus* in the earlier phase is by far larger than those for rats. To our regret it is quite uncertain that the value (1,41) of *Phenacomys* should be compared with that of any phase in the relative growth of the rat and mouse above quoted.

The fact that the relative tail length of the female is as a rule superior to that of the male in *R. losea* as well as in some species of rats in a wide range of body length, is according to PRIZBRAM ('25) to be at least partially attributed to the higher body-temperature indicated by the female than by the male.

Number of scale rings in cm. of tail.—The number of annuli was read, as noted previously, at the middle of the tail and moreover in the flesh specimen, due to the fact that the number in the stuffed specimen was found to tend to be counted below its true value (AOKI and TANAKA '35). As will be shown in fig. 2, the relationships between this value and head and body length may be expressed by the same formula as the equation of simple allometry, namely

$$y = 649{,}2\, x^{-0{,}797}$$

for the range of 97 mm. to 182 mm. in body length. However the exponent in the equation should be duly distinguished from the equilibrium coefficient in its biological implication, because the number of scale rings is a dimensionless number. The formula does not fit so well the data which hardly display sexual difference in the distribution of dots, for the average percentage deviation is 3,48%. It may be presumably caused by the greatly decreased number of specimens calculated.

From the negative value of the exponent of the formula, it can be recognized that the number of scale rings in a definite length de-

creases little by little as body length increases, at least nearly after the beginning of the second phase in the relative growth of tail length. The number of annuli either in unit length or in total length of the tail have been sometimes used as a diagnostic character for murine forms, but statistical researches so far as we are aware have rarely been carried out on them.

ERICKSON ('31) observed that the increase of scale rings in the albino rat is due to the formation of new rings on the growing tip and that there is an increase of about 30 percent, namely from 145 to about 190 in the total number of rings between three weeks and one year of age, with no apparent increase after one year.

If the situation of the ring-formation is true for our rat, the number of annuli in cm. at the middle of the tail might well be regarded as approximately an average number throughout the whole length. When the formula of simple allometry for the tail length is $y=bx^{\alpha}$ and that for the scale rings in unit length of tail is $y'=b'x^{-k}$, the total number of the rings (Y) may be expressed as follows:

$$Y=y\cdot y'$$

Hence we get a new exponential equation

$$Y=Bx^{\alpha-k},$$

where x is head and body length while B a new constant, as a formula giving a relationship between the total number of annuli and body length.

The exponent of this formula presents subsequent calculated values for the two phases in the relative growth of tail length.

	Second phase	Third phase
Male	0,179	−0,120
Female	0,343	−0,250

It would be therefore suggested that the total number of annuli is increased and thereafter reduced with increasing body size and the rate of increase and decrease is more marked in females. The calculated total number is about 169 for the largest males and about

179 for the largest females, being smaller as contrasted with that in the aibino rat.

Hind foot length and ear length.—As will be shown in figure 2 and table 9 there exist three distinct phases with different relative growth constants in the hind foot as well as in the ear, nearly paralleled by those in the tail. The striking sexual difference in the distribution of dots is brought out only in the third phase of the hind foot, in which the significantly distinguishable coefficient is given respectively for both sexes (table 9). The relative growth of these dimensions is always negatively allometric throughout three phases, except for the first phase of the ear length (α, 1,223), and the rate is gradually reduced with advancing phase until the female value of growth constant in the last phase is close to zero (0,0147), that is to say, an increase in the absolute length of the female hind foot is hardly made.

In so far as we can infer from the percentage curve of hind foot and ear lengths reduced to head and body length in the rats illustrated by NEGISHI ('31), the relative growth in them would be, roughly speaking, considered as close to isometry for the first brief phase, and thereafter it is, apparently, negatively allometric, but an occurence of the third phase such as found in our specimen is not distinctively suggested. However, even in our preliminary report, the third phase was not pointed out, although it seemed to exist obscurely.

The hind foot of the mouse, according to GREEN and FEKETE, has at least two phases of relative growth, the first of which shows markedly positive allometry (α, 1,73), followed by a greatly decreased rate of growth (α, 0,19), with a short indefinite transitional phase, equivalent to near the time of adolescence, between the first and the second.

As to sexual differences, NEGISHI ('31), judging from the percentage curves, recognised no remarkable discrepancy in the relative value of the ear length against head and body length in the rat, while found a pronounced superiority of the male over the female in

the proportionate length of the hind foot in adult forms of *Rattus norvegicus*. But GREEN and FEKETE took no account of sexual differences in the mouse.

Finally, summing up the values of the equilibrium constant (α) of relative growth in the hind foot as follows we have:—

Species	Sex	First phase	Second phase	Third phase	Author
Rattus losea	♂	0,846	0,461	0,161±0,0050	AOKI & TANAKA
	♀			0,0147±0,00513	
Rattus norvegicus norvegicus	♂ ♀	roughly speaking, near to 1	1 $>$; Male $>$ Female		NEGISHI ('31)
R. rattus alexandrinus	♂ ♀		1 $>$		
Mus musculus		1,73	*	0,19	GREEN & FEKETE ('33)

* indefinite transitional phase.

It is remarkable that we find positive allometry of a high degree with α equalling 1,73 in the earlier phase of the hind foot of the mouse, as contrasted with the negatively allometric tendency in the case of rats, the rate of growth being suddenly reduced in the later phase, with α nearly identical with that of the male in the third phase of *R. losea*.

Three phases in relative growth.—In tail, hind foot and ear, three distinct phases with different growth constants have respectively been found to occur approximately parallel to each other. The body size at the time of the change from one phase to the subsequent is described in table 9. Consequently, it may be summerised that against the postnatal increase of head and body length, the relative growth in tail, hind foot and ear is weakly negatively or positively allometric during the first short period (up to 80–90 mm. of body length), and then takes place the second phase which nearly maintains isometry for tail length while rather highly negative allometry for hind foot and ear, followed by the last phase, in which allometry is apparently

negative, especially marked in hind foot and ear, after a size of 135-145 mm. body length. The time of the last break might be thought to be near the onset of puberty.

Body weight.—In the present rat, body weight changes with increasing body size conforming to the exponential formula for a major part of the range of body length;

$$\text{body weight} = 0{,}000147 \text{ body length}^{2{,}658}$$

within a range of 85,5-155,5 mm. for males, 80,5-155,5 mm. for females. The data surpassing 155,5 mm. is not appropriated to this formula.

From the equation, it may be readily deduced that the specific weight of the body decreases with increasing body length, since the exponent is less than 3,0. An exponent of 2,67954 is computed for the mouse by GREEN and FEKETE ('33). According to their notes this figure is somewhat lower than that usually found in fishes, where it is slightly in excess of 3,0, but it is near to those of the rat showing 2,76 and 2,79 for males and females (recalculated by them from DONALDSON's data). Hence the value of exponent in our rat is nearly identical with that of the mouse.

VI. Relative growth in skull measurements.

Skull measurements adopted for study of relative growth will be illustrated subsequently.

(1) *Occipito-nasal length;* greatest length measured from tip of nasal to end of occipital in a horizontal line, which is designated in the present paper as a line passing along crown surface of maxillary tooth row. This dimension is taken as the standard of relative growth of the skull.

(2) *Nasal length;* from tip to naso-frontal suture.

(3) *Frontal length;* from naso-frontal suture to coronal suture in median line.

(4) *Frontal breadth;* distance between intersecting points of coronal suture and supra-orbital crest.

(5) *Parietal length;* from coronal suture to lambdoidal suture in median line.

(6) *Parietal breadth;* maximum distance between parietal crest on each side.

(7) *Interparietal length* and *breadth.*

(8) *Greatest rostral width;* maximum width of rostrum measured just in front of infroarbital foramen.

(9) *Least interorbital breadth;* minimum distance between orbital fossae measured at supra-orbital crest.

(10) *Greatest zygomatic width;* maximum distance between zygomatic arches.

(11) *Cranial width;* maximum distance at base of zygomatic process.

(12) *Breadth of foramen magnum.*

(13) *Basilar length;* distance from Basion* to Henselion.*

(14) *Condylo-basal length;* from Condylion* to Gnathion.*

(15) *Palatilar length;* from Palation* to Henselion.*

(16) *Diastema;* from tip of alveolus of first upper molar to Henselion.*

(17) *Length of incisive foramen;* from base of palatine process of premaxilla to base of that of maxilla.

(18) *Basicranial length;* distance from mid point of presphenoid-basisphenoidal suture to basion.

(19) *Palaltal width at tip of alveolus of first upper molar.*

(20) *Least palatal width at first upper molar;* minimum breadth measured at alveolus of first upper molar.

(21) *Basicranial width;* length of basisphenoid-basioccipital suture.

(22) *Rostral depth;* vertical depth of rostrum measured at center of palatal floor.

* Basion, Henselion, Gnathion, Condylion and Palation are cited from THOMAS ('05).

(23) *Cranial depth;* vertical depth of brain case at middle of anterior border of basioccipital.

(24) *Cranial capacity;* determined by weight of fine shot no. 11, with which brain case is filled as much as possible.

(25) *Incisive index;* angle between horizontal line and chord of entire forward curvature of extruded incisor (THOMAS '19).

(26) *Length of upper tooth row* and *width of first upper molar;* measured at upper margin of cingulum.

(27) *Length of mandible;* distance from last posterior point of angular process to most superior point of alveolus of incisor.

(28) *Depth of mandible;* depth of horizontal ramus of mandible measured at border between first and second molars.

Arithmetic treatment of skull measurements respecting relative growth in accordance with the simple allometry law is principally the same as in external measurements. All actual values were averaged being grouped according to each class, established on the base of occipito-nasal length with a class interval of one millimeter, instead of head and body length. The mean value and number of cases employed in calculation for every class are shown in table 10.

The logarithmic plotting of these skull measurements against occipito-nasal length and presentation of the theoretical lines are made in figures 3, 4, 5, 6 and 7. Calculation of growth constants and their probable errors have been accomplished by means of least squares using the same formulae as in the case of external measurements. These are shown in table 11.

For the cases of larger forms in all measurements, arithmetic analysis was attempted separately as to either sex in order to ascertain whether or not sexual dimorphism exists with regard to relative growth.

It is noticeably perceived particularly in plotting figures of skull measurements as compared with external ones, that dots for juvenile forms are inclined to depart farther from theoretical lines than those for adults do as a consequence of deficiency in weight of means for juveniles.

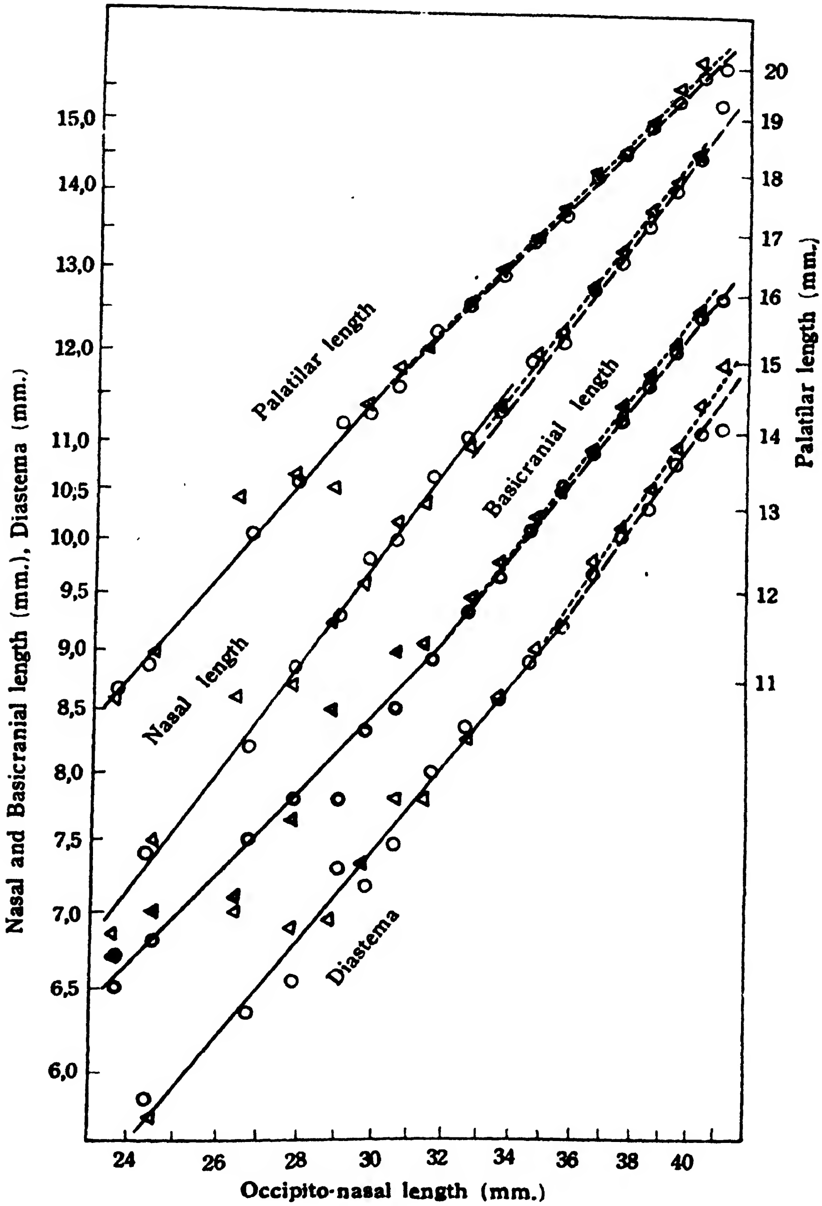


Figure 3.

Logarithmic plot of skull measurements on occipito-nasal length.
O, — — — for males; Δ, ------ for females;
——— common to both sexes.

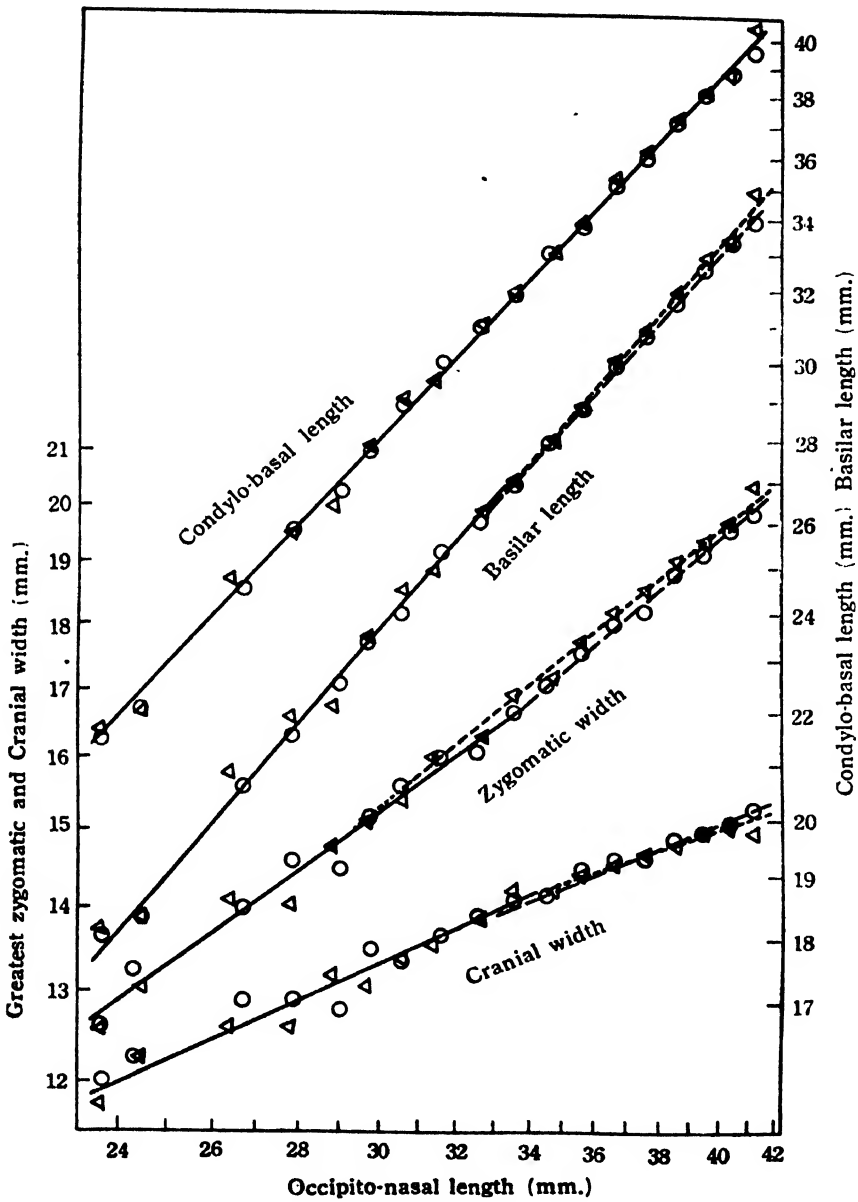


Figure 4.

Logarithmic plot of skull measurements on occipito-nasal length.
O, — — — for males; Δ, ------ for females;
———— common to both sexes.

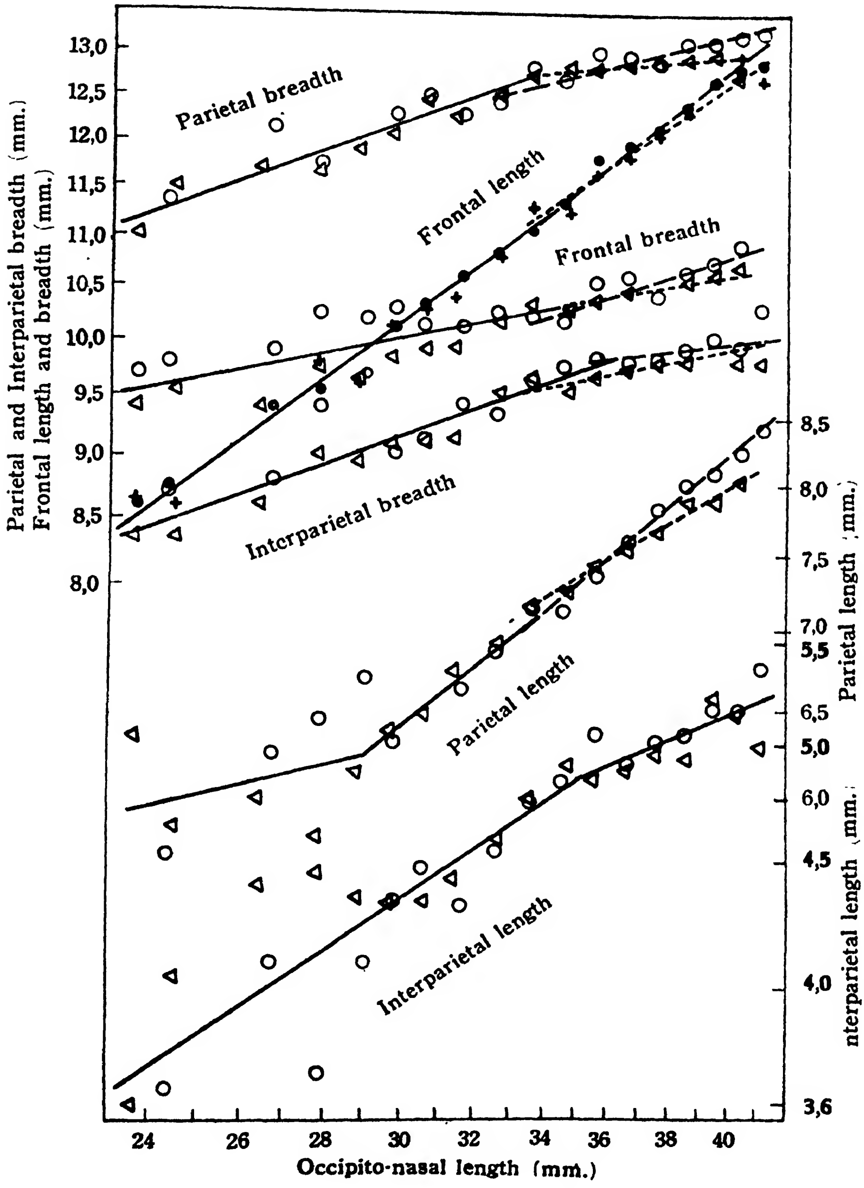


Figure 5.

Logarithmic plot of skull measurements on occipito-nasal length.
○, ●, — — — for males; △, ×, ------ for females;
——— common to both sexes.

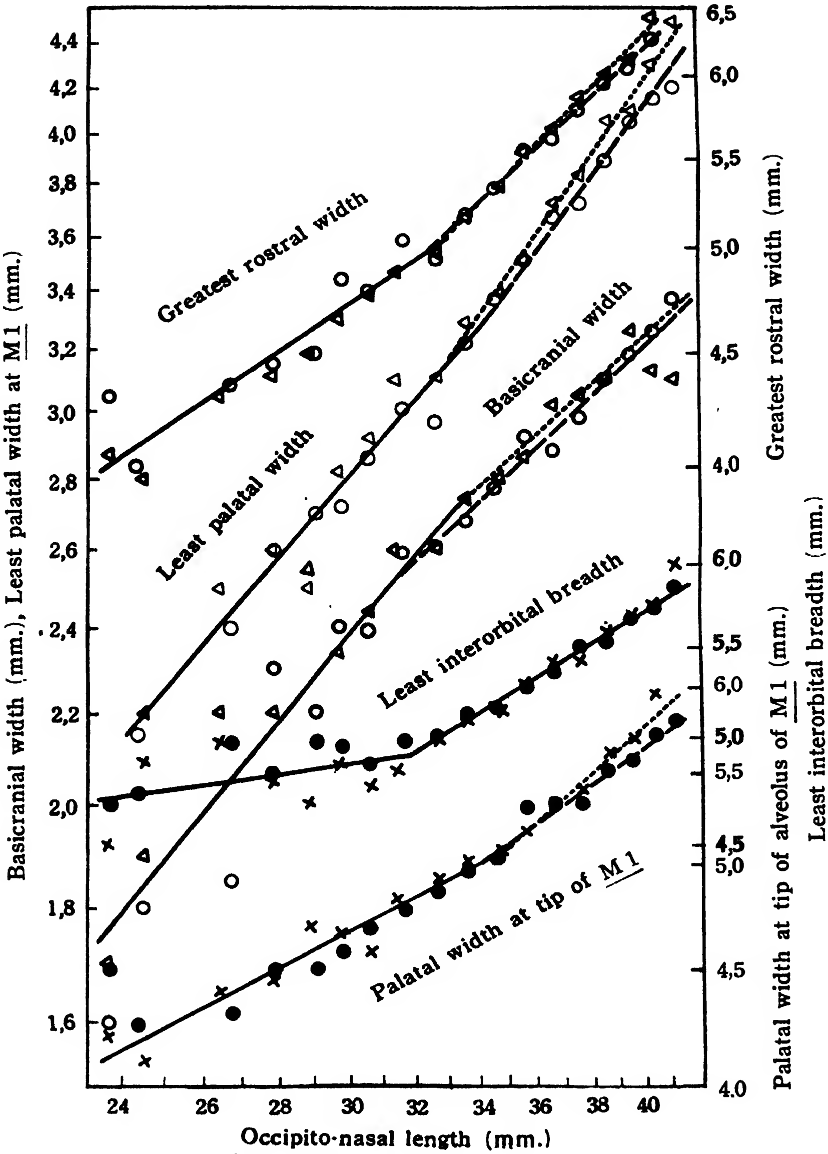


Figure 6.

Logarithmic plot of skull measurements on occipito-nasal length.

O, ●, — — — for males; △, ×, ------ for females.

———— common to both sexes.

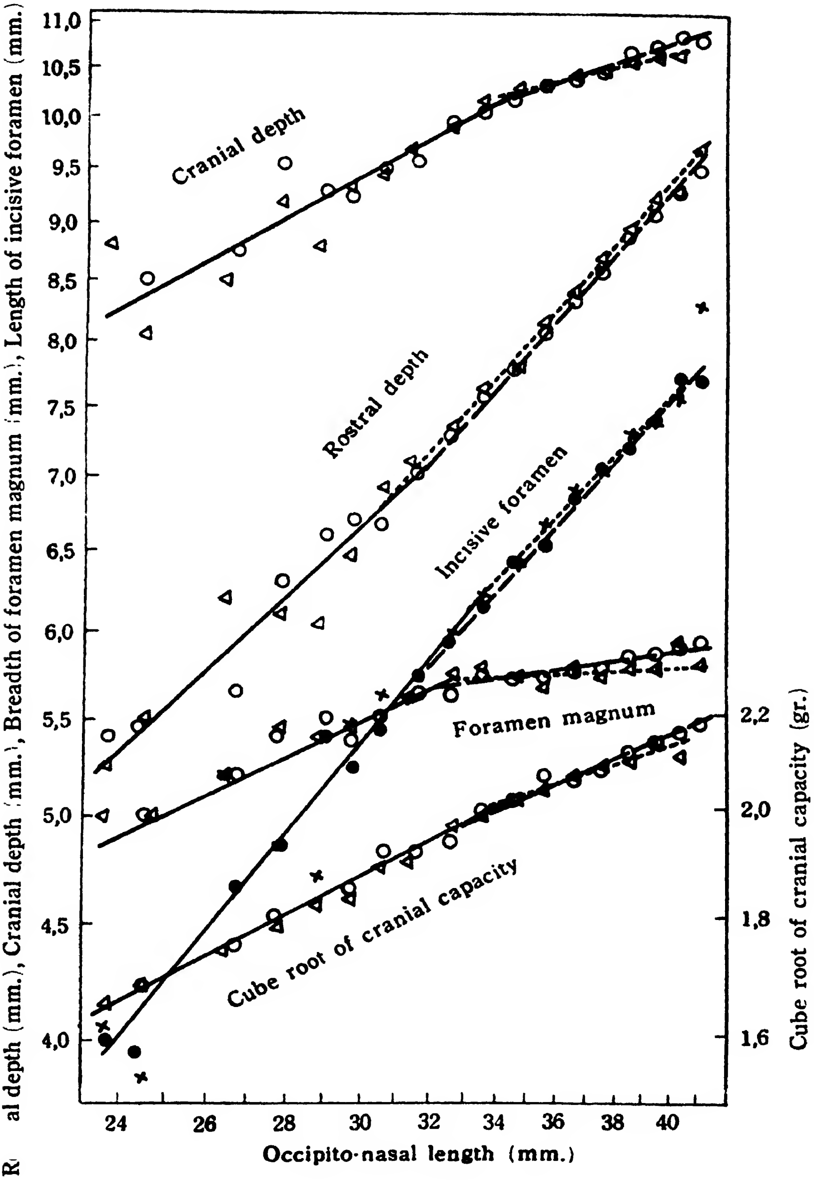


Figure 7.

Logarithmic plot of skull measurements on occipito-nasal length.
○, ●, — — — for males; △, ×, ------ for females;
———— common to both sexes.

TABLE 11. Equilibrium constants (α) and initial

Measurement	Sex	First phase α_1	First phase b_1	First phase Calculated class range	α_2 with p. e.
Nasal length	♂	1,4054	0,08213	*(1)-(10)	1,4017±0,0037
	♀				1,3758±0,0019
Frontal length	♂	0,7643	0,7568	(1)-(11)	0,8292±0,0027
	♀				0,7141±0,0049
Frontal breadth	♂	0,2097	4,909	(1)-(11)	0,3462±0,0049
	♀				0,1842±0,0024
Parietal length	♂	0,2484⊗	2,710⊗	(1)-(6)	0,9018±0,0039
	♀	0,8277⊗	0,3843⊗	(7)-(10)	0,6230±0,0038
Parietal breadth	♂	0,3837	3,309	(1)-(11)	0,2695±0,0035
	♀				0,0935±0,0030
Interparietal length	♂	0,6940	0,4109	(1)-(11)	0,4349±0,0068
					0,4511⊗
	♀				0,4143±0,0121
Interparietal breadth	♂	0,3802	2,517	(2)-(12)	0,1253±0,0036
	♀			(1)-(12)	0,2149±0,0051
Greatest rostral width	♂	0,7126	0,4193	(1)-(10)	0,9848±0,0033
	♀				1,0771±0,0036
Least interorbital breadth	♂	0,1471	2,968	(1)-(9)	0,6342±0,0023
					0,6387⊗
	♀				0,6458±0,0036
Greatest zygomatic width	♂	0,7632	1,139	(1)-(10)	0,9038±0,0022
	♀			(1)-(8)	0,8595±0,0023
Cranial width	♂	0,4835	2,579	(1)-(11)	0,4419±0,0027
	♀				0,3673±0,0018
Breadth of foramen magnum	♂	0,5021	0,9933	(1)-(10)	0,1583±0,0021
	♀				0,0547±0,0047
Basilar length	♂	1,2147	0,3796	(1)-(10)	1,1680±0,0009
	♀				1,2014±0,0022
Condylo-basal length	♂	1,1216	0,6180	(1)-(19)	1,1292±0,0018
					1,1216⊗
	♀				1,1236±0,0019
Palatilar length	♂	1,4054	0,08213	(1)-(10)	1,0495±0,0011
	♀				1,0629±0,0019
Diastema	♂	1,2592	0,1028	(2)-(11)	1,4997±0,0039
	♀				1,5697±0,0055
Length of incisive foramen	♂	1,2990	0,06479	(1)-(10)	1,1833±0,0033
	♀				1,1292±0,0054
Basicranial length	♂	1,0844	0,2124	(1)-(9)	1,3152±0,0013
	♀				1,3762±0,0025
Palatal width at tip of M 1	♂	0,5459	0,7314	(1)-(11)	0,7344±0,0061
	♀				0,9334±0,0052
Least palatal width at M 1	♂	1,2156	0,04499	(2)-(10)	1,4255±0,0039
	♀				1,5075±0,0061
Basicranial width	♂	1,2747	0,03118	(1)-(10)	0,9966±0,0055
	♀				0,9544±0,0086
Rostral depth	♂	0,9978	0,2236	(1)-(9)	1,2044±0,0020
	♀				1,1889±0,0029
Cranial depth	♂	0,5980	1,235	(1)-(11)	0,3730±0,0029
	♀				0,2686±0,0018
Cube root of cranial capacity	♂	0,5536	0,2843	(2)-(11)	0,4680±0,0036
	♀			(1)-(11)	0,3561±0,0031

* The class number qouted in table 10. ⊗ common to both sexes.

growth indexes (b) for skull measurements.

Second phase						α_1 minus α_2	Occipito-nasal length(mm) at break
Sex difference of α_2	Diff./p. e.	b_2	Sex difference of log b_2 with p. e.	Diff./p. e.	Calculated class range		
0,0259±0,0042	6,2	0,08145 0,09033	0,0449±0,0061	7,0	(11)-(18)	0,0037 0,0296	32,0-34,0
0,1151±0,0055	20,9	0,6015 0,9078	0,1788±0,0037	20,6	(11)-(19)	-0,0649 0,0502	34,0 33,0-35,0
0,1620±0,0055	29,5	3,011 5,379	0,2520±0,0086	29,3	(11)-(18) (11)-(19)	-0,1365 0,0255	35,0-36,0
0,2788±0,0054	51,6	0,2956 0,8015	0,4331±0,0080	54,1	(11)-(19)	— —	35 0-36,0
0,1760±0,0046	38,3	4,896 9,191	0,2736±0,0074	37,0	(12)-(19)	0,1142 0,2902	33,0-35,0 33,5
0,0206±0,0139	1,5	1,039 **0,9750⊗** 1,108	0,0276±0,0228	1,2	(12)-(19)	0,2429	35,0
0,0896±0,0062	14,5	6,279 4,490	0,1456±0,0098	14,9	(12)-(19)	0,2549 0,1653	36,0 33,5
0,0923±0,0049	18,8	0,1630 0,1177	0,1416±0,0077	18,4	(11)-(19)	-0,2722 -0,3645	32,0-33,0
0,0116±0,0043	2,7	0,5498 **0,5411⊗** 0,5273	0,0181±0,0067	2,7	(10)-(19)	-0,4916	32,0
0,0443±0,0032	13,8	0,6934 0,8230	0,0744±0,0049	15,2	(11)-(19) (9)-(19)	-0,1406 -0,0963	33,5 29,5-30,5
0,0746±0,0032	23,3	2,965 3,883	0,1171±0,0050	23,4	(12)-(19)	0,0416 0,1162	32,5-35,0 34,5
0,1041±0,0051	20,4	3,267 4,724	0,1602±0,0081	19,8	(11)-(19)	0,3433 0,4474	32,0 32,5
0,0334±0,0024	13,9	0,4444 0,3959	0,0502±0,0037	13,6	(11)-(19)	0,0467 0,0133	32,0-34,0
0,0056±0,0026	2,2	0,6003 **0,6180⊗** 0,6146	0,0102±0,0041	2,5	(11)-(19)	—	—
0,0134±0,0022	6,1	0,4081 0,3911	0,0184±0,0034	5,4	(7)-(19)	0,3559 0,3425	30,0
0,0700±0,0067	10,4	0,004352 0,003421	0,1046±0,0106	9,9	(12)-(19)	-0,2405 -0,3105	35,5 34,5
0,0541±0,0063	8,6	0,09594 0,1177	0,0876±0,0098	8,9	(11)-(19)	0,1157 0,1698	30,0 33,5
0,0610±0,0028	21,8	0,09557 0,07738	0,0917±0,0043	21,3	(10)-(19) (10)-(18)	-0,2308 -0,2918	31,5
0,1990±0,0080	24,9	0,3762 0,1847	0,3090±0,0126	24,5	(12)-(19)	-0,1885 -0,3875	34,0 35,0
0,0820±0,0072	11,4	0,02141 0,01625	0,1198±0,0114	10,5	(11)-(19)	-0,2099 -0,2919	34,5 32,5
0,0422±0,0102	4,1	0,08116 0,09574	0,0718±0,0161	4,5	(11)-(19)	0,2781 0,3203	31,3 33,0
0,0155±0,0035	4,4	0,1091 0,1166	0,0290±0,0055	5,3	(10)-(19)	-0,2066 -0,1911	32,3 30,5
0,1044±0,0034	30,7	2,729 3,969	0,1628±0,0054	30,1	(12)-(19) (12)-(18)	0,2250 0,3294	34,0 34,5
0,1119±0,0048	23,3	0,3834 0,5733	0,1747±0,0075	23,3	(12)-(19) (12)-(18)	0,0856 0,1975	32,5 34,5

Nasal.—(see fig. 3) It is worth while paying much attention to the fact that growth of nasal length is strongly positively allometric with α being always near to 1,40 throughout whole series of class ranges. In the distribution of cases for larger forms, a significantly distinguishable formula of simple allometry is given respectively for either sex, because of sexual difference in values of constant α as well as b being over 6 times as large as their probable errors, but it seems that no sexual difference exists in the distribution of cases for juvenile forms. Accordingly, alteration in rate of relative growth may be inferred to take place at about 32,0–34,0 mm. skull length.

Frontal.—(see fig. 5) For frontal length and breadth, relative growth is all the times negatively allometric, especially intensely negatively in the latter (α, 0,2097), that is to say, not only the relative values of breadth and length of frontal against skull size but the ratio of breadth to length becomes reduced with increasing skull size. Significantly different values of constants can be applied to both sexes in the later phase, particularly the difference in breadth being striking, while values both in earlier and later phases keep approximately similar. Break in growth rate occurs at 33,0–35,0 mm. of skull size for length of frontal, while 35,0-36,0 mm. for breadth.

Parietal.—(see fig. 5) In earlier phase of parietal length, the negatively allometric equilibrium constant indicates 0,2484 and 0,8277. It is questionable whether or not these values are consistently significant in so far as the present material is concerned. In the later phase, significantly different equations are to be found to fit respectively the data for the two sexes, and cases for males are distributed over those for females.

The growth in parietal breadth is far more markedly negatively allometric in the later phase as compared with that of parietal length, so that it is suggested, as is the case in the frontal, that the relative value of parietal breadth to length becomes progressively much decreased during the later period.

Interparietal.—(see fig. 5) Interparietal length and breadth show negative allometry with a more reduced rate in the later than in the

earlier phase. The analytic test to ascertain sexual difference in respect of relative growth was tried for cases in the later phase, but it failed to produce significant data in the case of length, for the values of difference either in a or in logarithm of b are only 1,2 to 1,5 times their problable errors, while in the case of breadth the sexual difference is appreciably approved.

Allometric growth is in any case more strongly negative in breath than in length, hence it may be readily comprehended that the ratio of breadth to length always diminishes with increasing entire skull size.

Greatest rostral width.—(see fig. 6) Two distinct phases exist with different growth rates. In the first phase the equilibrium constant displays 0,7126, while in the second 0,9848 for males and 1,0771 for females, in other words, growth is nearly isometric and rate of change is slightly but significantly larger in females.

Least interorbital breadth.—(see fig. 6) As will be seen in the figure, the rate of relative growth suddenly increases at 32,0 mm. skull size passing from highly negative allometry with a being 0,1471 in the first phase, to negative allometry in the second with 0,6387, which is a common value for both sexes, since mathematical analysis has tried in vain to bring out significant sexual differences in the growth constants for the second phase.

Greatest zygomatic width.– (see fig. 6) As shown in fig. 6, two significantly different lines with a equalling 0,9038 and 0,8595 are separately drawn through the cases of either sex in the second phase. The growth is made at a slightly lower rate (a, 0,7632) in the first phase than in the second. The break occurs at 33,5 mm. of the entire skull length for males, while at 29,5–30,5 mm. for females.

Cranial width.—(see fig. 4) Despite the fact that the distribution of cases in the figure appears to suggest no appreciable sexual difference in relative growth constants in the later phase of cranial width, we have been led to recognize a slight but significant difference between values of constants for the two sexes. However the two lines intersect at about the middle of the later phase (37,0 mm. skull

size). In the later phase the growth is reduced in rate, though it is always negatively allometric.

Dorsal aspect of skull.—(see fig. 8) From the above descriptions of the relative growth of skull measurements which would appear to exert some influence on the configuration of dorsal aspect of the skull, the principal formal changes in the dorsal view may be summarised here.

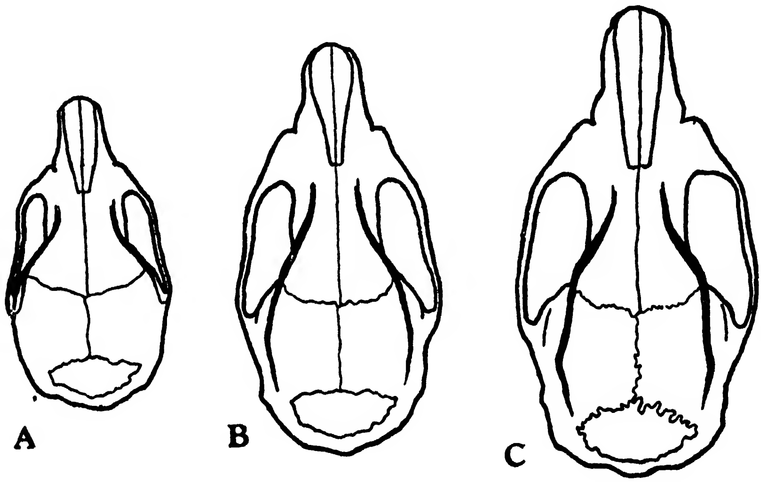


Figure 8.
Dorsal aspect of the skull in three phases, juvenile (A), adolescent (B) and old (C). (8/5 enlarged)

In the first place, the nasal length shows a remarkable increase in relative value, because it undergoes highly positively allometric growth throughout the whole postnatal period. The same nasal feature is seen in *Otospermophilus* (Hall '26).

In the frontal and parietal as well as interparietal, the proportionate value of length against breadth which is, strictly speaking, the distance between the supra-orbital ridges in either side—except in the case of the interparietal – becomes enlarged progressively with advanced age, in accordance with the statement by Allen (1894) that in respect to the breadth of the skull the variations with growth are much less than in its length.

Side by side with these changes, the supraorbital and parietal

ridges of weak development become by degrees strengthened and angular. Needless to say, the cranial width likewise decreases proportionately. Thus the general form of the brain case having a smoothly rounded contour is made progressively rather oblong and decidedly angular.

Rostral width exerts but little effect on the dorsal aspect, because it remains roughly constant in its relative value in response to the development of the rostrum, but the least interorbital breadth decreases its relative value rapidly, as is the case with the same measurements in *Neotoma* (ALLEN) or *Microtus* (HOWELL) and the postorbital breadth in *Otospermophilus* (HALL).

The greatest zygomatic width undergoes no great change in its proportion, but the contour of the zygomatic arch varies to a high degree being associated with masseteric development, namely the convexity of the arch is increasingly developed with age, on this account the position where maximum breadth may be measured is forced to gradually migrate anteriorly with growth.

Basilar length and condylo-basal length.--(fig. 4) These lengths assume growth of pronouncedly positive allometry with α equalling 1,1 to 1,2 throughout two phases. Two significantly distinguishable formulae may fit cases for either sex, respectively, in the later phase of basilar length, while such a sexual difference fails to be found for condylo-basal length.

Diastema and palatilar length.—(fig. 3) The allometric growth of diastema abruptly increases in its rate from the first to the second phase, but the situation is reversed in the case of that of palatilar length. As a consequence, regardless of the fact that the growth for both measurements is positively allometric, particularly strongly in the case of the latter, in the first phase, the former shows highly positive allometry with α significantly differing for each sex, namely 1,4997 for males and 1,5697 for female, in the second phase, while the latter quite isometry in the second.

Length of incisive foramen.—(fig. 7) As the length of the incisive foramina on each side can be seen to be distinctively different from

each other, the length of the intervening part of palatine processes, which is regarded as mean value of them, was chosen as an object for measurement. According to the analysis of this dimension, the incisive foramen shows a slightly lower rate of positively allometric growth in the second phase than in the first. Sexual difference in the growth constants for later phase may be significantly calculated.

Palatal width at tip of first upper molar.—(fig. 6) This measurement might be considered as one of real palatal distance between the upper molar series on either side. Although the relative growth of the dimension is invariably negatively allometric, the rate of growth is made to increase in the later phase, with considerable abruptness in the case of female, in which the value of the constant is even 0,9334.

Least palatal width at first upper molar.—(fig. 6) This dimension is commonly given as palatal width. It is worthy of great attention that the measurement clearly indicates positively allometric growth, especially strongly in the later phase, because α is 1,4255 in males and 1,5075 in females, in spite of that it is of a similar nature and located adjacent to the just cited palatal width which has merely a negatively allometric growth.

Basicranial length.—(fig. 3) The basicranial length designated here as from the presphenoid-basisphenoidal suture to the basion, shows nearly isometric growth during the first period while it is apparently positively allometric, taking significantly different values of the constant (α, 1,3152 or 1,3762) for each sex, respectively, in the second phase.

Basicranial width.—(fig. 6) On the contrary, the growth of the width, i. e. length of the anterior border of the basioccipital, is positively allometric in the first phase, nevertheless it is close to isometry in the second, with α being 0,9966 for males and 0,9544 for females. The sexual difference in the value of α amounts short of sufficient statistical significance, but that in the value of $\log b$ is 4,5 times its probable error.

Breadth of foramen magnum.—(fig. 7) The relative growth of

this dimension is positively allometric throughout the whole growth and the rate of growth is slightly decreased in the later phase.

Rostral depth and cranial depth.—(fig. 7) Notwithstanding the fact that the growth of the rostral depth is nearly isometric in the first phase and furthermore positively allometric in the second, that of the cranial depth is all the times pronouncedly negatively allometric, particularly to a considerable degree in the second phase (α, 0,3730 for males and 0,2686 for females).

This tells us how considerable amount of relative increase the rostrum undergoes as compared with the cranium proper especially in its later development. The male formula applied to cases in the later phase differs significantly from the female one for the same phase appreciably in cranial depth, but approximately in rostral depth, because the sexual difference of α for the latter is 4,4 times its probable error.

∛*Cube root of cranial capacity.*—(fig. 7) The cube root of weight in grams of fine shot with which the brain case is filled as possible, is plotted double-logarithmically on the occipito-nasal length. As a consequence, it may be concluded that one side of the cranial cube shows negative allometry, with a smaller rate of relative growth in the later phase than in the earlier.

Incisive index and molar dimensions.—Some relationships between occipito-nasal length and incisive index, upper molar tooth row length and width of first upper molar are displayed in fig. 9. The parallel lines to abscissae drawn through the plotted cases in these three dimensions represent the mean values calculated from the whole adult skulls* having an occipito-nasal length of over 34,0 mm.

In so far as we are aware from the figure, it would appear justifiable to believe the adult mean value is kept with considerable propriety during the whole period of growth at least in the case of the molar breadth and incisive index.

We should take notice that the incisive index, which was num-

* Determination of adult skulls based on the skull size will be described in a later paragraph.

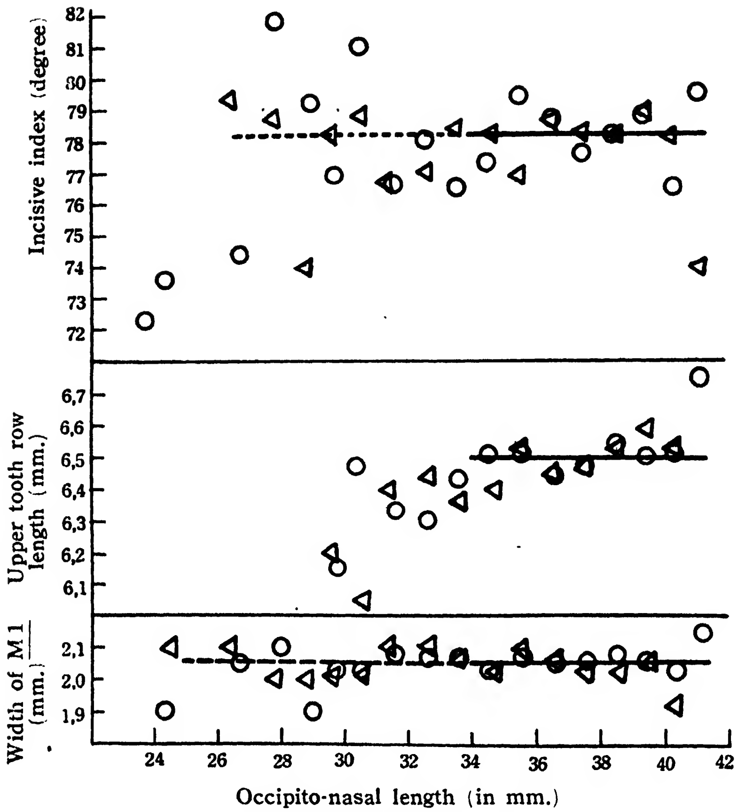


Figure 9.

Plot of incisive index, upper tooth row length and width of first upper molar against occipito-nasal length. O for males; △ for females.

erically defined and emphasized by THOMAS ('19) remains approximately the same value of about 78° for both sex, showing a large amplitude of individual variation on each side of the mean line, so the present rat is stated to be "*opisthodont.*"

It is commonly accepted that mammalian teeth with perfect roots make no linear growth after eruption. The evidence inconsistent with the knowledge was pointed out in the albino rat by DONALDSON and FRENCH ('27), but it was later refused by WOOD and WOOD ('91).

The fact that erupted rat molars are incapable of diametric increase may be apparently indicated by the relative growth of breadth of the first upper molar in the present wild rat, while it is roughly

recognisable only for the cases of skull size of above 34,0 mm. in the case of upper tooth row length.

These are explained subsequently. The dimension, as before described, was taken along the upper margin of the cingulum, that is partially displayed with a weak line in fig. 12, lest we should assume erroneous measurment due to attrition of the crown surface. On this account, the measurement of the first molar erupting out first of all was relatively accurately obtained, while tooth row length inclined to be measured short of the true value during the period from 30 mm. to 34 mm. of skull size, before which the three crown surfaces do not yet attain to full eruption.

In short the molar of our rat may well be deemed also as showing no diametric growth after eruption.

Ventral and lateral aspect of skull.—(see fig. 10 and 11) The longitudinal dimensions of measurements make relative growth of higher rate than transverse dimensions do in general also in the ventral aspect of the skull. For instance, in each of basilar length, condylobasal length, palatilar length, diastema, length of incisive foramen and basicranial length, to a greater or lesser degree positive allometry

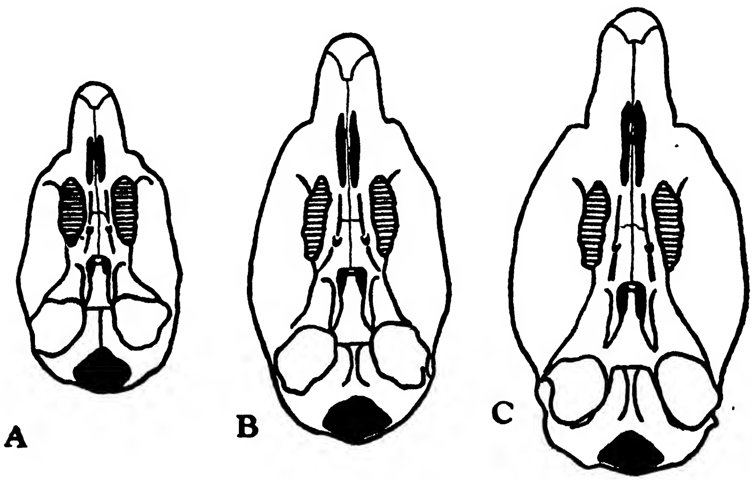


Figure 10.
Ventral aspect of the skull in three phases, juvenile (A), adolescent (B) and old (C). (8/5 enlarged)

is accomplished throughout all phases. The tooth row length, of course, is only one exception.

As contrasted with them, the growth of width of skull comprising palatal breadth at tip of the first molar, breadth of foramen magnum and basicranial breadth, is negatively allometric, besides the first phase of basicranial width.

Notwithstanding the least palatal width at the alveolus of first molar shows so high value of growth constant, which would seem to be quite inconsistent with the fact that the same dimension in the ground squirrel is provided with the highest stability in skull growth, (HALL).

If we take into consideration non occurrence of a linear dimension of the molar after eruption, the inconsistence will be readily eliminated. The palatal width measured at tip of the molar representing the true distance between the molar series on each side, undergoes negative allometry with α being never lower and the least palatal width roughly corresponds to the residual of the true distance minus the width of one molar, hence the least palatal width is caused to be fairly small in the juvenile phase owing to relatively larger molar width and *vice versa* in the adult phase. Such a veritable situation may be somewhat illustrated by the alteration of the relative position of palatine foramen against the molar row, as shown in the ventral view of the skull (fig. 10).

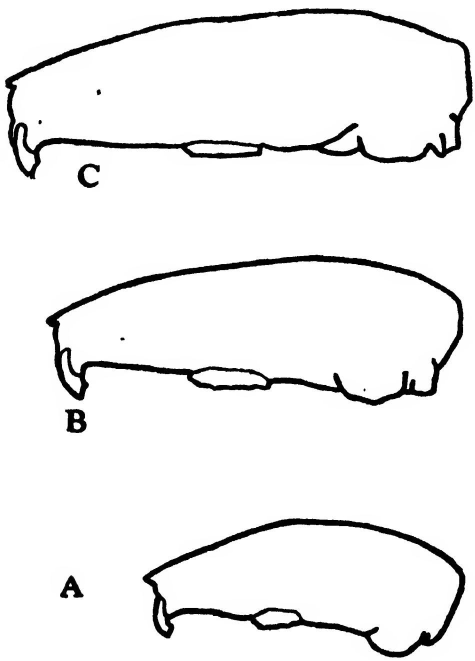


Figure 11.
Lateral contour of the skull in three phases, juvenile (A), adolescent (B) and old (C). (8/5 enlarged)

Accordingly we believe that the least palatal width at the first molar would never prove an advisable measurement denoting the true manner of growth change in palatal width, such is not the case with the ground squirrel.

As to growth modification in the lateral view of the skull, the rostral depth has a magnified rate of relative growth in the second than in the first phase correlated with growth of the rostrum, the situation is reversed in the cranial depth, such as is pointed out in *Neotoma* by ALLEN, in response to which the convexity of the cranial roof and the forward slope of the rostral roof become progressively decreased, also ensued by rapid increase in length of various basal portions of the skull (fig. 11).

Mandible.—The length of mandible shows positive allometry with α equalling 1,111 until 38,0 mm. skull length, and thereafter a short while negative allometry for a round value of α is 0,757, nevertheless the depth of mandible is incessantly nearly isometric (α, 1,088). The relative value of depth to length in the mandible itself, consequently, has a tendency to be reduced though at a very slight rate.

VII. Characteristics of molar cusps.

The crown surfaces of the cheek-teeth are displayed in figure 12. The variation in the cusps of the molar teeth has been observed on about one hundred and eighty skulls provided with perfectly erupted but slightly worn teeth, and as a consequence of the statistical treatment of the results, the following features may be summarised, as compared with those of *Rattus norvegicus* and *R. rattus* according to BARRET-HAMILTON ('10–'16).

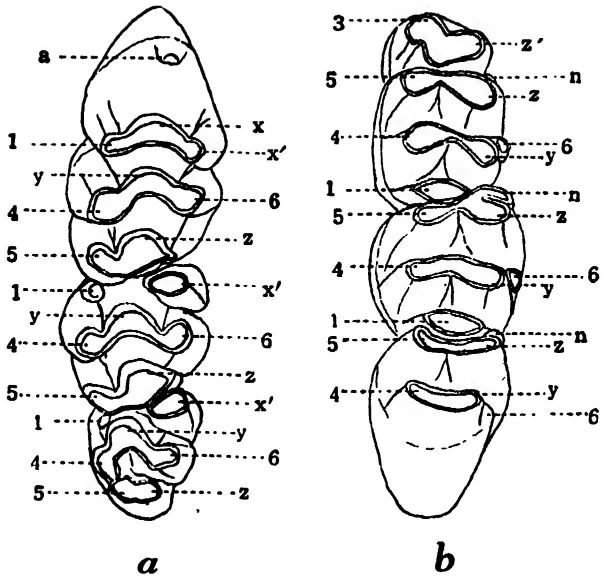


Figure 12.

Showing the crown surfaces of the right upper (a) and lower (b) molars, the homologous cusps of which are similarly lettered or numbered conforming with the theory of trituberculy. Coll. No. 248, female, × 10.

	Teeth and cusps	*Rattus rattus* (from BARRET-HAMILTON)	*Rattus norvegicus* (from BARRET-HAMILTON)	*Rattus losea*
M¹	Anterior basal cingulum.	as a rule, there is no trace at all.	usually present.	usually present and anterior accessory cusp (a) occasionally occurs (60%).*
	Cusp 1	distinct and usually nearly as large as *x*.	much smaller than *x* and fused with it from relatively early.	smaller than *x* and fused with it as in *rattus*.
	Cusp 4 & 5	—	smaller than in *rattus* and more intimately connected with *z* and *y* respectively.	relatively smaller than in *rattus* but not so much as in *norvegicus*.
M²	Cusp 1	—	— (all distinguished when slightly worn.)	obviously found in 50%.*
	Cusp 4	—	rather well developed, though smaller than in *rattus*. (all distinguished when slightly worn.)	developed as much as in *norvegicus*.
	Cusp 5	still evident though partially fused with *z*.	— (all distinguished when slightly worn.)	nearly as evident in *rattus*.

The percentages indicate relative frequency computed from the data.

Teeth and cusps		*Rattus rattus* (from BARRET-HAMILTON)	*Rattus norvegicus* (from BARRET-HAMILTON)	*Rattus losea*
M^3	Cusp 1	minute trace occurs occasionally.	all distinguished when slightly worn.	minute or vestigial or quite absent (25%).*
	Cusp 4	—		distinguishable in most cases as in *norvegicus*.
	Cusp 5	completely lost.		
M_1	Cusp *n*	more vestigial and may be wholly absent.	absent	vestigial or extinct (25–30%).*
	Cusp 6	apparently a constant feature.	minute.	minute and extinct only in 3%.*
M_2	Cusp *n*	—	present though small.	present though minute as in other species.
	Cnsp 6	—		
M_3		rather more simplified than in *norvegicus*.	—	rather similar to in *norvegicus*.
	Cusp 6	—	—	present mostly though very minute.
	Cusp *n*	—	present though small	present though small.
	Posterior lobe	when quite unworn, distinct traces of 4 and *y* seen.	when slightly worn, intimately connected tubercles of *y* and 4 seen.	intimately fused tubercles of *y* and 4.
General features		Outer cusp slightly less reduced and median tubercle in upper teeth slightly less developed than in *R. norvegicus*.	Slightly more specialised than in *R. rattus*. In the upper molar the median tubercles somewhat increased in size while outer row is more reduced and the tendency towards lophodonty is more marked. In the lower teeth also the outer row is more reduced than in *rattus*.	In upper molars, outer row is slightly more reduced than in *rattus* but not so much as in *norvegicus*. In the lower molars, the outer row is developed as much as in *rattus*, but M_3 is not so simplified as in the latter.

The percentages indicate relative frequency computed from the data.

From the above comparison of these three species, it may with propriety be concluded that *Rattus losea* is an intermediately specialised form between *R. rattus* and *R. norvegicus* in so far as the general character of the cusp of the cheek-teeth is concerned.

VIII. General consideration on relative growth in the skull.

A general comparison of the relative growth in all skull measurements concerning either with elemental bones or compositive parts will be undertaken so that we may understand as a whole the manner of change in form of the skull along with growth.

As described in the foregoing paragraphs, two distinct phases of relative growth take place with different values of growth constants in the major number of measurements, although in a few the same value is kept invariably throughout whole growth, and in addition a sex difference of statistical significance may be proved as to the value of growth constants in the later phase of most measurements.

It is a matter of importance that the break in the rate of relative growth from the first to the second phase occurs approximately simultaneously, namely at 30 mm. to 36 mm. occipito-nasal length, except only in the case of parietal length, where the time of break from the second to the third phase agrees with that from the first to the second in others.

The dimensions are allowed to be rearranged as follows from table 11 according to the order of magnitude of the equilibrium constant;

Earlier phase		Later phase			
		Male		Female	
Nasal length.	1,4054	Diastema.	1,4997	Diastema.	1,5697
Palatilar length.	„	Least palatal width.	1,4255	Least palatal width.	1,5075
Length of incisive foramen.	1,2990	Nasal length.	1,4017	Basicranial length.	1,3762
Basicranial width.	1,2747	Basicran. leng.	1,3152	Nasal length.	1,3758

Earlier phase		Later phase			
		Male		Female	
Diastema.	1,2592	Rostral depth.	1,2044	Basilar length.	1,2014
Least palatal width.	1,2156	Length of incisive foramen.	1,1833	Rostral depth.	1,1889
Basilar length.	1,2147	Basilar length.	1,1680	Length of incisive foramen.	1,1292
Condylo-basal length.	1,1216	Condylo-basal leng.	1,1216	Condylo-basal length.	1,1216
Basicranial length.	1,0844	Palatilar leng.	1,0495	Greatest rostral width.	1,0771
Rostral depth.	0,9978	Basicranial wid.	0,9966	Palatilar leng.	1,0629
Frontal length.	0,7643	Greatest rostral width.	0,9848	Basicranial width.	0,9544
Greatest zygomatic width.	0,7632	Greatest zygomatic width.	0,9038	Palatal width at tip of M'.	0,9334
Greatest rostral wid.	0,7126	Parietal length.	0,9018	Greatest zygomatic width.	0,8595
Interparietal length.	0,6940	Frontal length.	0,8292	Frontal length.	0,7141
Cranial depth.	0,5980	Palatal width at tip of M'.	0,7344	Least interorbital width.	0,6387
Cube root of cranial capacity.	0,5536	Least interorbital width.	0,6387	Parietal length.	0,6230
Palatal width at tip of M'.	0,5459	Cube root of cranial capacity.	0,4680	Interparietal length.	0,4511
Parietal length.	*(0,5380)	Interparietal length.	0,4511	Cranial width.	0,3673
Breadth of foramen magnum.	0,5021	Cranial width.	0,4419	C. r. of cranial capacity.	0,3561
Cranial width.	0,4835	Frontal width.	0,3462	Cranial depth.	0,2686
Parietal width.	0,3837	Cranial depth.	0,3730	Interparietal width.	0,2149
Interparietal width.	0,3802	Parietal width.	0,2695	Frontal width.	0,1842
Frontal width.	0,2097	Breadth of foramen magnum.	0,1588	Parietal width.	0,0935
Least interorbital width.	0,1471	Interparietal width.	0,1253	Breadth of foramen magnum.	0,0547

* A mean of two values of constant in the earlier phase.

Generally speaking, in the case of earlier as well as later phases for each sex, most measurements ranking at the upper orders in this list may be included in the preorbital region of the skull, such as nasal length, diastema, rostral depth, palatilar length, length of incisive foramen etc., and in the basicranial part, for instance the basicranial length and width. The noticeably great value of least palatal width at the first upper molar is not worth being compared with the others on account of the previously illustrated reasons (see p. 50).

On the contrary most measurements ordered below are to be comprised in the postorbital region exclusive of the basicranial part, for example interparietal width and length, parietal and frontal widths, cranial breadth, width of foramen magnum, cranial depth, cube root of cranial capacity etc.

Two measurements, the least interorbital breadth and the palatal width at the tip of first molar to be included into the interorbital region, show highly smaller value of the constant in the earlier phase, nevertheless their order in this list is moved considerably upwards in the later phase. The frontal length, also located in the same region, always keeps the intermediate order, but frontal breadth is one of measurements showing the smallest amount of increase.

Accordingly, judging from the order of magnitude of equilibrium constant it may be summarised that the preorbital region undergoes the greatest amount of increase and in the second place the increase of basicranial part is marked, while the interorbital and postorbital regions, excepting the basicranial part, apparently reveal a smaller amount of change during postnatal development.

The same features have been pointed out in *Neotoma micropus* by ALLEN. HALL stated that the rostral region, especially the back side of the cranium, and the basicranial region undergo the greatest amount of increase in the skull of *Otospermophilus*, and this would perhaps be a common feature for most mammals. He moreover concluded that the most stable portion of the skull is the interorbital region and that the greatest amount of increase is earliest accomplished in the postorbital region, and latest in the preorbital.

If the measurements are arranged according to the order of the magnitude of difference $(a_1 - a_2)$ between the equilibrium constants in the earlier and in the later phase, the following list will be derived from table 11.

Male		Female	
Least interorbital width.	−0,4916	Least interorbital width.	−0,4916
Greatest rostral width.	−0,2732	Palatal width at tip of M^1.	−0,13875
Diastema.	−0,2405	Greatest rostral width.	−0,3645
Basicranial length.	−0,2308	Diastema.	−0,3105

Male		Female	
Least palatal width at M^1.	−0,2099	Least palatal width at M^1.	−0,2919
Rostral depth.	−0,2066	Basicranial length.	−0,2918
Palatal width at tip of M^1.	−0,1885	Rostral depth.	−0,1911
Greatest zygomtic width.	−0,1406	Greatest zygomatic width.	−0,0963
Frontal width.	−0,1365	Condylo-basal length.	0
Frontal length.	−0,0649	Basilar length.	0,0133
Condylo-basal length.	0	Frontal width.	0,0255
Nasal length.	0,0037	Nasal length.	0,0296
Cranial width.	0,0416	Frontal length.	0,0502
Basilar length.	0,0467	Cranial width.	0.1162
Cube root of cranial capacity.	0,0856	Interparietal width.	0,1653
Parietal width.	0,1142	Length of incisive foramen.	0,1698
Length of inciseve foramen.	0,1157	C. r. of cranial capacity.	0,1975
Cranial depth.	0,2250	Interparietal length.	0,2429
Interparietal length.	0,2429	Parietal width.	0,2902
Interparietal width.	0,2549	Basicranial width.	0,3203
Basicranial width.	0,2781	Cranial depth.	0,3294
Breadth of foramen magnum.	0,3433	Palatilar length.	0,3425
Palatilar length.	0,3559	Breadth of foramen magnum.	0,4474

As a consequence of an examination of the list, it will be approximately comprehensible, in the case of both sexes, that measurements of the postorbital region have a tendency to rank in the lower order, for instance palatilar length, breadth of foramen magnum, basicranial width, interparital length and width, cranial depth etc., with the exception of only the basicranial width which is located fairly above. Those to be included in the pre- and interorbital regions, such as greatest rostral width, diastema, rostral depth etc. for the former case and least interorbital width, least palatal width at M^1, palatal width at tip of M^1 etc. for the latter case, tend to take precedence in the order of the list.

Consequently we may say in general that the greater amount of increase is accomplished at an earlier time in the postorbital region of the skull, while it occurs at a later one in the preorbital as well as interorbital region. Such is nearly the case with *Otospermophilus*, but it is unknown to us in so far as present data are concerned, whether any one of the latter two regions precedes another.

TODD ('33, '34) described postnatal skull growth in hyaena and sheep on the basis of qualitative observation. According to him, the later growth of the hyaena skull is much simpler than that in sheep

or pigs, although the principles of growth are identical. There is a backling of the face on cranium in sheep, none in hyaena. A practical cessation of growth occurs in the hyaena brain case after eruption of the permanent carnassial teeth. The cranial growth resolves itself first into extension of muscular scaffolding and condylar migration and secondly into actual extension accessory to the facial growth. In the hyaena the facial growth in brief is a simple thrusting of the maxilla forward from beneath the frontal. It is more complicated in sheep. There is a hafting zone, namely orbit and palato-pterygoid area, exerting a mechanism of adjustment between facial and cranial growth change.

The above situation is also consistent principally in the case of the skull of rodents. The hafting zone just quoted may be regarded as the interorbital region in the latter, hence it is probable that the measurement located in this region continues to increase its size hafting face to cranium until later together with the marked development of the preorbital region. In short, the interorbital region in the skull of the present rat failed to prove to be "a dead center," as suggested in the papers of HOWELL and HALL.

GREEN ('33) described that the extistence of a growth-gradient in the mature mouse skull comprising strains of *Mus bacterianus*, *Mus musculus* and their hybrid and back-cross, can be recognised, namely the mean values of α for the four classes increase in the following order; cranial breadth, cranial height, interorbital width, width outside molars, zygomatic width, rostral height and cranial capacity.

In our rat, after measurements are divided in three groups of different direction, *viz.* breadth, length and depth, they are arranged in the following order according to the value of α.

First phase

Breadth: Least interorbital < Frontal < Interparietal < Parietal < Cranial < Breadth of foramen magnum < Palatal width at tip of M^1 < Greatest rostral < Greatest zygomatic < Basicranial.

Length: Parietal < Interparietal < Frontal < Basicranial < Diastema < Length of incisive foramen < Palatilar < Nasal.

Depth: Cranial < Rostral.

Second phase (male)

Breadth: Interparietal < Breadth of foramen magnum < Parietal < Frontal < Cranial < Least interorbital < Palatal width at tip of M^1 < Greatest zygomatic < Greatest rostral < Basicranial.

Length: Interparietal < Frontal < Parietal < Palatilar < Length of incisive foramen < Basicranial < Nasal < Diastema.

Depth: Cranial < Rostral.

Consequently, only in case of the width in the first phase, it appears to show absence of growth-gradient, nevertheless it is approximately justifiable to say that in other cases there exists a growth-gradient, though not decidedly, provided with growth-center distally or anteriorly also in the rat skull exclusive of basicranial measurements, as is the case with the mouse.

Sex distinction has been statistically demonstrated concerning growth constant in the later phase of most skull measurements. Only three dimensions, namely interparietal length, least interorbital breadth and condylo-basal length, of all the measurements examined and compared in this study, revealed insignificant sex differences in the values of the constants. As will be seen in fig. 3, 4, 5, 6 and 7 the significantly distinguishable lines are drawn through the points only in the dimensions with sex difference, to give respectively a goot fit for each sex.

Among these however the female line is located wholly or partially above the male one in some measurements, the reverse situation occurs in others, that is to say, a male and a female of the same absolute skull size will possess different values of measurement, a female being superior over a male in the former and inferior in the latter case.

The former group comprises palatilar length, nasal length, basicranial length, diastema, basilar length, greatest zygomatic width, greatest rostral width, least palatal width at M^1, basicranial width, palatal width at tip of M^1, rostral depth and length of incisive foramen, and the latter group includes parietal length and breadth, frontal length and breadth, interparietal breadth, cranial depth, breadth of

foramen magnum and cube root of cranial capacity, while cranial width is an intermediate between both groups. It seems worth while paying considerable attention to the fact that the dimensions to be included in the first group display a value of α larger than or near to 1 at least, on the contrary α of the second group is decidedly smaller than 1.

We are led to the conviction that, in general, the rate of growth in absolute length of the male skull with advancing age is to a larger or lesser degree greater than that in the female, hence a female will be older than a male with the same skull length as the former. When a relative value of a measurement reduced to entire skull length is made to increase with progressing age for both sexes, the relative value for a female exceeds that for a male against the same absolute skull size, and when it is decreased with age, the reversed situation ensues.

Accordingly the above stated first group of measurements showing mostly positive allometry or nearly isometry can be regarded as the former instances and the second group mostly showing highly negative allometry as the latter examples. The relative value of cranial width and least interorbital breadth would remain almost invariable with age.

GREEN and FEKETE concluded from the calculation of the partial crorrelation between relative dimension, age and body length in *Mus* that in early stages, age tends to be of more importance than size in relative growth, the roles later being reversed.

The reasons why sex difference is seen as to the distribution of points on the graph of relative growth will be grossly, though not thoroughly, brought to light by the above interpretations. No one has as yet argued these respects, in so far as we are aware. The relatively remarkable distinction of the relative length of zygomatic width in the female, already pointed out in our previous papers, should deserve mention.

The conclusions principally similar though different in some points were presented in our preliminary reports (AOKI and TANAKA '34,

'35) after we had subjected to otherwise mathematical analysis, namely the use of a linear formula $y=bx+m$, instead of the allometry formula $y=bx^k$. Moreover a determination of these constants was made by a mere graphic method in the former case instead of by least squares as in the present. Although it has not been ascertained by detailed mathematical analysis which is more accurately fit, both would appear to have a similar fitness to the range of our material. The fitness of the formulae in the present study is represented by the average percentage deviation of 0,60-3,00%. It will be therefore more reasonable and convenient that the present universally available formula, the biological implication of which is extensively brought to light, should be employed.

IX. Determination of the size at which sexual maturity is attained.

As described in the foregoing paragraphs, summing up transitional stage from juvenile to adult status in the coloration of pelage, the tail shade and the grade of its bicoloredness, as well as in the stripe of hind foot one may say that it exists as a whole at a body length of nearly 120 mm. with a range of 110-130 mm. the female preceding slightly the male in size.

In the rate of relative growth of tail, hind foot and ear length referred to head and body length, two breaks take place at about a corresponding size for eaeh measurement respectively, but the first break (at 80-90 mm.) as yet fails to be connected with any physiological status, while the second (at 135-145 mm.) may be considered as closely associated with the attainment of sexual maturity.

The major part of skull measurements examined here afford a break in the rate of relative growth at a skull size of 29,5 to 36,0 mm. for both sexes, as will be seen in table 11, no sexual difference being recognised in this respect, most frequently at 32-35 mm. skull size.

GREEN and FEKETE reported in *Mus* that in several limb bones a distinct break in the growth rate occurs near the time of attainment

of sexual maturity. Unfortunately, a comparison of growth rate during pre-maturity with that during post-maturity as to skull parts is not reported.

The degree of correlation between occipito-nasal length (X) and head and body length (Y) can be determined by PEARSON's correlation coefficient (r). The following value was computed from the present material:

$\bar{r}=0{,}913$ for male,

$\bar{r}=0{,}916$ for female.

These measurements as one would expect proved to be to a high degree correlated with each other. From the regression equation in this correlation, we will obtain the subsequent corresponding values for X and Y;

when X is	30 mm.,	a mean of Y is	103,6mm.	in male,	101,2 mm.	in female.
„ „	33,5	„ „	125,7	„	121,6	„
„ „	36,0	„ „	141,4	„	136,1	„

Consequently, the body size range (110-130 mm.) at the transitional stage of external characters and that of external measurements at the time of break (135-145 mm.) may be together roughly included into the skull size range (30-36 mm.) at break. It is to be noted that the break in external measurements occurs latest among those above compared. In so far as the maximum relative tail length is concerned, it may be conjectured that adolescence is attained in the second phase or at least at the end of it.

Finally, taking into consideration the average times of these breaks as a whole, sexual maturity will be attained approximately at 33-37 mm. skull size or 120-140 mm. body length. According to the results of the statistical examination on the opening of vaginal orifice and the descending of testis in this rat, the details of which will be described elsewhere, such a reasoning appears to be also justifiable.

Roughly speaking, the full eruption of the third molar is finished at 100-120 mm. body length and the original pattern of the crown surface of the cheek-teeth gets extinct at 130-145 mm.

Lately, AOKI and MATSUMOTO ('36) found in the same specimen

that the male arrives at adult state in the distribution of parietal cells in the stomach at 130 mm. head and body length and the female at 120 mm.

After all it seems reasonable that the following smallest size chiefly based on the mean time of breaks in skull measurements, should be for convenience adopted for the purpose of determining the size limits for adult specimens;

	Head and body length	Occipito-nasal length
Male	126 mm.	34,1 mm.
Female	121 mm.	34,1 mm.

The values of these measurements approximately correspond to each other respectively.

X. Individual variation and mean value of adult measurements.

As argued by HUXLEY ('31), the majority of animals show unlimited growth. Even among mammals a change of proportion may occur throughout life. In the voles (HINTON '26) and in the albino rat (STRONG '25), the skeletons apparently continue to grow, though at a slow rate, long after adult state has been reached, accompanied by continuous change of proportions.

The relative growth of skull and external measurements in the adult stage, in other words in the second or third phase, has been comparatively discussed and interpreted in the foregoing paragraphs.

The individual variation or fluctuation of most adult measurements is incapable of being studied quite apart from the influence of growth, owning to above described reasons, when a large series of age-unknown wild rats is dealt with as in the present study. Therefore the mean values of measurements may be more or less dependent upon the method of determination of adult forms of the whole series of specimens. Nevertheless there may occur a few measurements showing no actual increase at least in the later period such as molar dimensions, the fluctuation of which are best examined independent of growth.

The study of relative growth teaches us that the size factor plays a very important role in the determination of adult range. As a result, as previously stated, we have regarded the specimen provided with a larger size beyond a certain definite limit as an adult.

TABLE 12.

Adult mean values and coefficients of variation for external measurements.

Measurement	Sex	Number of cases	Mean with P. E.	Difference with P. E.	Diff./P. E.	Standard deviation (σ)	Coefficient of variation	Difference with P. E.	Diff./P. E.
Head and body length	♂	326	153,1±0,49	10,7±0,71	15,1	13,25	8,65±0,23	-0,16±0,35	
	♀	269	142,4±0,52			12,55	8,81±0,26		
Tail length	♂	308	145,8±0,51	−1,2±0,75	1,6	13,15	9,05±0,25	0,21±0,37	
	♀	248	146,5±0,55			12,95	8,84±0,27		
Hind foot length	♂	324	30,2±0,05	1,1±0,07	15,7	1,51	5,00±0,13	0,64±0,18	3,6
	♀	263	29,1±0,05			1,27	4,36±0,13		
Ear length	♂	321	19,3±0,05	0,2±0,07	2,9	1,17	6,06±0,16	-0,33±0,25	1,3
	♀	262	19,1±0,05			1,22	6,39±0,19		
Number of scale rings in cm. of tail	♂	48	12,1±0.12	−0,5±0,17	2,9	1,26	10,41±0,72	0,01±1,00	
	♀	51	12,6±0,12			1,31	10,40±0,69		

Note: Specimens calculated are provided with head and body length larger than 125 mm. in males, 120 mm. in females.

The mean values and coefficients of variation in the external measurements of adult specimens are given in table 12. As will be seen in this table, the male exceeds significantly the female in head and body length as well as in hind foot length, but in tail length, ear length and number of scale rings in cm. of tail, sex difference is insignificant. The residual of head and body length minus tail

length equals $7,8 \pm 0,71$, namely eleven times its probable error for males, while $-4,1 \pm 0,76$, namely 5,4 times its probable error. Hence body length is significantly superior to tail length in the male, with the reversed situation in the female.

According to BARRET-HAMILTON, in *Rattus rattus* the tail is usually longer, never noticeably shorter, than the head and body, while *R. norvegicus* has a shorter tail which is never as long as the head and body. It is therefore of great interest that our present rat should retain just an intermediate situation between these allied rats, bearing in mind the same disposition as to the cusp pattern of molars.

The superiority of the male hind foot length of the females was recognised by NEGISHI ('31) in *R. norvegicus.* LATIMER ('36) found one of the chief sex differences in the longer extremities in the male adult cats.

The above results in the present paper is principally the same as that in our preliminary report, even if some distinction in the magnitude of means can be seen due probably to different lower limit for determination of adult size, but the slightly higher value for the number of scale rings is assignable to the method of numbering different from the one formerly adopted.

Sex difference bearing on the coefficient of variation in external measurements is too small to be of full significance, since it is necessary for a difference to amount over 4,5 times its probable error in order to become significant. Above all, however, sex difference is most noticeable in the hind foot.

Among these measurements, the hind foot length is most invariable and the number of scale rings the most variable.

The frequency curves of head and body length and hind foot length are shown in figure 13. It may be deemed to be of approximate symmetry and near to a normal curve in hind foot length, while it may well be also stated to have a tendency to be a normal curve, although it is assymmetrical because of the determination of the adult range by a definite size limit.

TABLE 13. Adult mean values and coefficients of variation for skull measurements.

Measurement	Sex	Number of cases	Mean with P. E.	Difference with P. E.	Diff./P. E.	Standard deviation (σ)	Coefficient of variation	Difference with P. E.	Diff./P. E.
Occipito-nasal length	♂	279	37,89±0,069	0,61±0,102	6,0	1,705	4,50±0,13	0,28±0,19	1,5
	♀	202	37,28±0,075			1,575	4,22±0,14		
Nasal length	♂	279	13,29±0,034	0,17±0,051	3,3	0,85	6,39±0,18	0,24±0,28	
	♀	202	13,12±0,038			0,81	6,15±0,21		
Least interorbital breadth	♂	274	5,50±0,010	0,04±0,015	2,7	0,26	4,65±0,13	0,42±0,19	2,2
	♀	201	5,46±0,011			0,23	4,23±0,14		
Greatest zygomatic width	♂	269	18,51±0,034	0,04±0,051		0,84	4,55±0,13	0,23±0,20	1,2
	♀	198	18,47±0,038			0,80	4,32±0,15		
Cranial width	♂	274	14,77±0,018	0,10±0,027	3,7	0,44	2,97±0,09	0,13±0,13	1,0
	♀	200	14,67±0,020			0,42	2,84±0.09		
Basilar length	♂	275	31,02±0,067	0,44±0,104	4,2	1,66	5,35±0,16	−0,08±0,24	
	♀	199	30,58±0,080			1,66	5,43±0,18		
Palatilar length	♂	278	18,53±0,037	0,22±0,057	3,9	0,92	4,99±0,14	−0,01±0,22	
	♀	202	18,31±0,043			0,92	5,00±0,17		
Length of incisive foramen	♂	266	7,10±0,018	0,10±0,028	3,6	0,44	6,25±0,18	0,11±0,25	
	♀	194	7,00±0,021			0,43	6,14±0,18		
Diastema	♂	279	10,15±0,029	0,12±0,045	2,7	0,71	7,00±0,20	−0,28±0,31	
	♀	201	10,03±0,034			0,73	7,28±0,24		
Least palatal width at M^1	♂	276	3,81±0,013	0,02±0,020	1,0	0,31	8,16±0,24	−0,05±0,37	
	♀	200	3,79±0,015			0,31	8,21±0,28		
Palatal width at tip of M^1	♂	276	5,43±0,011	0,02±0,018	1,1	0,27	4,95±0,14	−0,47±0,23	2,0
	♀	201	5,41±0,014			0,29	5,42±0,18		
Cranial depth	♂	275	10,59±0,016	0,10±0,023	4,3	0,39	3,64±0,11	0,63±0,15	4,2
	♀	197	10,49±0,016			0,32	3,01±0,10		
Rostral depth	♂	276	8,68±0,021	0,08±0,032	2,5	0,51	5,92±0,17	0,08±0,26	
	♀	201	8,60±0,024			0,50	5,84±0,20		
Breadth of M^1	♂	251	2,06±0,005	0,01±0,008	1,3	0.12	5,73±0,18	0,02±0,27	
	♀	187	2,05±0,006			0,12	5,71±0,20		
Upper tooth row length	♂	239	6,50±0,009	0,01±0,014		0,22	3,45±0,11	0,21±0,16	1,3
	♀	175	6,49±0,011			0,21	3,24±0,11		
Incisive index	♂	276	78,2±0,17	0,1 ±0,25		4,20	5,37±0,16	0,45±0,23	2,0
	♀	199	78,1±0,18			3,84	4,92±0,17		

Note: Skulls calculated are provided with occipito-nasal length larger than 34,0 mm. in both sexes.

The mean values and coefficients of variation of some skull measurements with their significant ratios are shown in table 13.

In respect to sex discrimination in the mean values, the male tends in general to surpass the female in every skull measurement compared here, but the difference never goes so far as to be of full significance, with the exception of the occipito-nasal length, in which apparent sex distinction can be verified. It is of border-lined significance in the basilar length and cranial depth. Notwithstanding, the difference may be considered as of significance by some morphologists, when it is greater than three times its probable error.

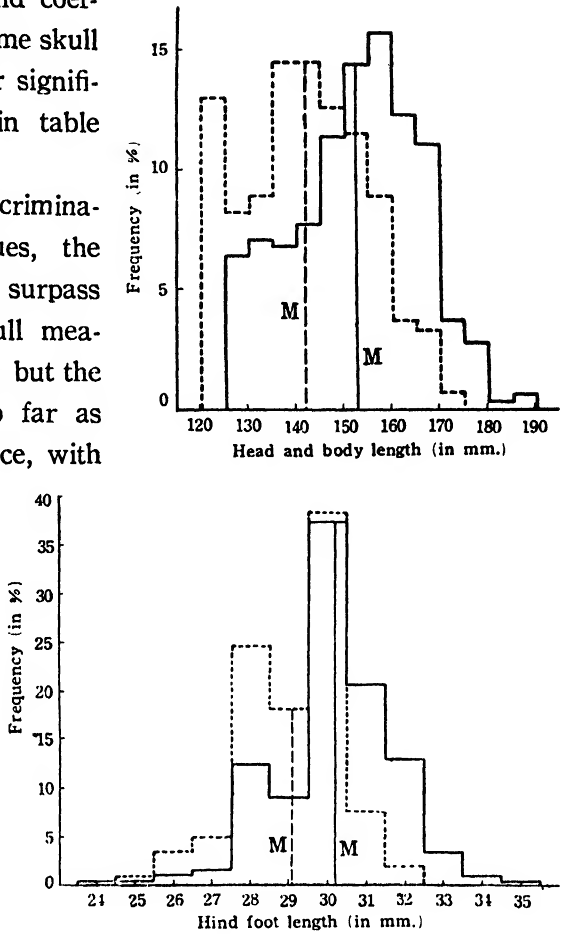


Figure 13.
Frequency polygon of head and body length and hind foot length in adult form. Solid line for male, broken line for female.

The adult mean values and their coefficients of variation for several skull measurements in the albino rat is reported by HATAI ('07 a) to be generally greater in males than in females. The same tendency is indicated by LATIMER ('37) in the skunk skull.

In addition, according to HATAI, the male nasal length of the albino rat reveals a marked superiortiy to that of the female not only in the mean actual values but in the relative value referred to

entire skull length. Such a feature in the nasal bone could be scarcely recognised in our rat, because the sex difference of the actual mean value is never particularly pronounced and the relative value is rather in the reversed situation, as will be comprehensible in fig. 3.

It is worth noting that as described by GREEN ('32) several skull measurements in the mature mouse (*Mus musculus*, *M. bactrianus*) show a general trend of inferiority of the male in the mean length as compared with the female.

The breadth of molar, tooth row length and incisive index, upon which growth would exert hardly any effect, may be considered to continue these constant mean values throughout life or at least during the later period.

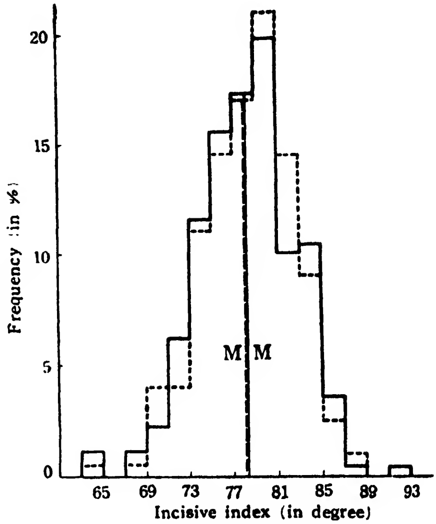
The males have but little a tendency to exceed the females in the coefficient of variation for the measurements above quoted, but among these sex difference is slightly marked in the cranial depth.

First of all, we should notice the greatest variability in the least palatal width at first upper molar, which has been interpreted to be most likely to afford an erroneous suggestion of a character of the palatal width. The cranial width is the most invariable and the cranial depth occupies the second place, as recognised in the albino rat (HATAI). It may well be understood that the greater variability appears in dimensions of the rostral region, for instance diastema, nasal length, length of incisive foramen. The occipito-nasal length and two dimensions of the interorbital region, least interorbital width and least palatal width at tip of upper first molar, occupy a middle place as regards variability.

The molar breadth, tooth row length and incisive index never show coefficients of variability as small as might be expected. Especially the higher value of the molar breadth, as compared with that of the tooth row length, might presumably be due to inaccuracy of measuring.

The frequency curve of the occipito-nasal length and incisive index are shown in fig. 14, from which the range of variation of

these measurements will be readily seen. The curve for the former is somewhat assymmetrical due to the same reasons as in the case of head and body length, but that for the latter, the fluctuation of which is regarded as nearly independent of growth, appears to be more approximate to a normal curve.



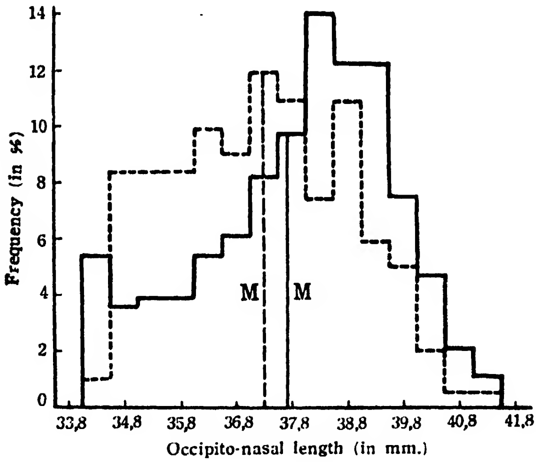


Figure 14.
The frequency polygon of occipito-nasal length and incisive index in the adult form. Solid line for male, broken line for female.

XI. Summary.

(1) Biostatistical researches on a Formosan wild rat *Rattus losea* (SWINHOE, 1870), working with northern forms including 784 skins and 614 skulls have been carried out with special reference to diagnostic characters for taxonomy. The qualitative characters were analyzed by means of the correlation table, while the quantitative ones were investigated in accordance with HUXLEY's law of simple allometry.

(2) In general, the dorsal coloration of pelage becomes lighter with increasing body size, as the ventral gray shade becomes paler, the overlaid yellowish tinge on the belly relatively increases, while the demarction line becomes though very slightly more indistinct. The tail-shade becomes lighter and the grade of bicoloredness decreases, though to a minute degree, with age. The hind foot stripe also fades. Individual variation is most remarkable in the hind foot stripe of these characters. The plantar tubercle is the most invariable. The only sex difference recognisable is in the grade of bicoloredness of the tail. In so far as age variations for these characters are concerned, three phases of pelage may be confirmed, the juvenile, the adult and the transitional.

(3) Tail length, hind foot length and ear length indicate three distinct phases in the rate of relative growth against head and body length and the first breaks, which yet fail to be connected with any physiological state, occur at 80-90 mm. head and body length, while the second breaks may be related to adolescence. In the first short phase, the relative growth is weakly negatively or positively allometric for these dimensions, followed by the second phase, where tail almost shows isometry while the hind foot and ear reveal negative allometry. In the last phase the growth of all is negatively allometric, especially marked in the hind foot and ear. Sex dimorphism as to growth constants is verified in the last phase of tail and hind foot.

(4) Body weight and number of scale rings in cm. of tail also apply to the formula of simple allometry at least during part of the growth period. The value of the equilibrium coefficient for the former is very close to that of the house mouse. From the formulae for the latter and for tail length, a new formula of the same form for the total number of scale rings can be derived.

(5) Two distinct phases in the rate of relative growth against occipito-nasal length may be denoted by the majority of skull measurements, the breaks occur at about the time of adolescence. From the comparative consideration of equilibrium constants for these the following may be concluded: (a) The preorbital region undergoes

the greatest amount of increase and in the second place there is a marked increase of the basicranial part, while in the interorbital and postorbital regions, excepting the basicranial part, apparently the smaller amount of increase is seen. (b) The greater amount of increase is accomplished at an earlier time in the postorbital region of the skull, while it takes place at a later one in the preorbital as well as interorbital regions. (c) There exists, though not decidely, a growth-gradient with center anteriorly in the length, breadth, and depth of the skull excepting basicranial dimensions, respectively, at least in the adult phase.

(6) Sex difference may be significantly demonstrated as to growth constants of most skull measurements in the adult phase, where the female line tends to be located above the male one, *i. e.* the females have a larger relative value than the males against the same skull size, in measurements showing positive allometry or almost isometry, with the reversed situation in those showing negative allometry. It might well be explained by the relation between the relative dimension and the age.

(7) The least palatal width at the first upper molar seems most likely to erroneously suggest growth change in the palatal width at least in this rat, and moreover it is the most variable among adult skull measurements compared, hence it would be an inadvisable dimension for taxonomic diagnosis.

(8) Breadth of first upper molar, tooth row length and incisive index may be regarded as invariable dimensions, scarcely influenced by growth, throughout life or at least in the adult. This rat is always opisthodont in the average.

(9) Investigation of cusp variation of the molar resulted in bringing out the fact that this rat is an intermediately specialised form between *Rattus rattus* and *R. norvegicus* in so far as the general features in the molar pattern are concerned.

(10) Sexual maturity is attained approximately at 33-37 mm. occipito-nasal length or 120-140 mm. head and body length.

(11) In the adult mean values, head and body length is signifi-

cantly supperior to tail length in the male, with the reversed situation in the female. The hind foot in males is larger than that in females. The male tends in general to exceed the female in the adult mean value of every skull measurement compared. Male nasal length never reveals a marked superiority to that of a female either in the mean actual value or in the relative value. Greater variability generally seems to be shown in the measurements of the rostral region and lesser in those of the cranial region among dimensions compared.

(12) The frequency polygons of adult values in some measurements are given.

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Seasonal Variations in the Pelage Characters of a Formosan Wild Rat, *Rattus losea* (SWINHOE).

Ryô TANAKA

CONTENTS.

I. Introduction.

It was pointed out by us (AOKI & TANAKA '38) that some seasonal variation also occurs in the pelage of this rat, when a large series of specimens was dealt with in order to perform a biostatistical research with regard to the various kinds of variation of diagnostic characters for taxonomy, in which the seasonal variation was not considered. Here the biostatistical analysis has been tried to ascertain evidence of seasonal variations, working with the same adult specimens.

Although many studies have been carried out on a mammalian hair with reference to its morphological characteristics, knowledge concerning seasonal variation and moults may be regarded as rather inadequate generally as regards wild mammals. Seasonal changes of

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the coat color, however, in winter-white mammals, such as wild hares and small carnivores, have since formerly received much attention for the purpose of disclosing the relation between the white winter and the summer hair. When describing the diagnostic characters of mammals new to science, the distinguishable coat colors for the winter and summer season may sometimes be given, nevertheless to what degree the seasonal agent will exert influences upon the variation of their diagnostic characters, as compared with the other factors, is as yet not very clear.

The specimens were all collected from the Basin of Taihoku in the northern part of Formosa, hence this study will throw some light on the problem of the summer and winter pelage of wild mammals inhabiting subtropical regions.

The author is highly indebted to Prof. Bunichirô AOKI, director of the Laboratory, for offering many instructive criticisms and to Prof. Yosio ABE, of the Zoological Institute of Hirosima University, for lending his important collection of works on the subject.

II. General characters of adult pelage.

Adult pelage on the dorsum consists in general of three kinds of hairs. Very abundunt and fine, slightly undulated hairs (Fig. 1, c) which constitute the greater part of the underfur are, basally, of a slatey color, with a subterminal Ochraceous* or Ochraceous Buff band and a black tip. The general dorsal coloration is largely dependent upon the subterminal shade of the hairs. The overhair consists of two kinds of longer and coarser hair. One of them is a spine (Fig. 1, a), basally of a dilute slate color, distally black in color, while the other is longer but finer than the former and of a black color, fading slightly toward the base (Fig. 1, b). The black parts of the overhair may have a considerable effect on the dark hue of the pelage. Of the three hairs the longest black hair is the smallest in quantity and is chiefly distributed towards the rump.

* All the capitalized color terms in this paper are cited from RIDGWAY (1886).

Besides the above mentioned kinds of hairs, we sometimes encounter another type of hair of indefinite size which most likely appears to be an intermediate form between the spinal hair and that of the underfur, because of the fact that it is provided with a subterminal ochraceous band notwithstanding its spine-like external shape.

On the ventral surface, the overhair is composed of only one type of hair, probably corresponding to the dorsal spine, which is of a white or very dilute color throughout its length, while the underfur is slatey in color, with a white or very slightly colored tip.

The general dorsal colors of the adult pelages are dark Ochraceous in the major part of the specimens, the next most frequently found being dark Ochraceous Buff, while dark Buff, Cinnamon or Russet, and Wood Brown or Hair Brown, are rare.

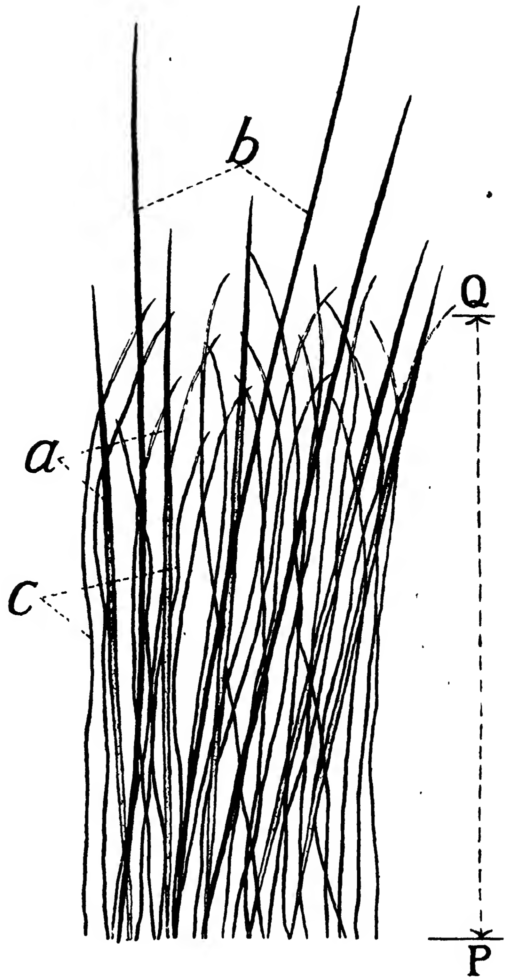


Figure 1.
Diagramatic figure of a part of the dorsal pelage, showing the spine (a), longer but finer black overhair (b) and the underfur (c). PQ is an average underfur length measured.

The ventral side is as a whole washed with an underlying gray color, over which a yellowish or whitish tinge is more or less suffused. The gray color corresponds mostly to Gray 9 of RIDGWAY, sometimes to Gray 8, rarely to Gray 10 or 7. The suffused yellowish tinge is most frequently pale Cream Color or Primose Yellow, rarely Straw

Yellow, Cream Buff or Buff. The yellowish tinges are in many cases to a greater or lesser degree added by whitish tinge. In rare cases only a whitish shade is found on the ventral surface.

III. Seasonal variation in the pelage.

a) Coarseness of the pelage.

The coarseness of the pelage as a whole may doubtless be due to various physical characters of its hairs, *e. g.* the diameter and the shape of the cross section, the relative depth of the cortex, the structure of the scale and others, amongst which the diameter of the hair appears to be one of the most effective agents.

In this study the whole series of the specimens, including both sexes, have been classified into four groups according to the grade of coarseness of the pelage. The characteristics of these groups, adopted as a standard of ranking, are subsequently explained. These characters were chiefly investigated on the dorsum of the pelage.

Group IV covers the specimens bearing an extremely coarse pelage, which is usually thinner and looser, and always possessed of markedly developed spines. The diameters of the spine as well of the underfur hair indicate the largest mean values among those of all groups. On the contrary, the specimens with a pronouncedly soft pelage are included in Group I. This is usually thicker and denser, and always bears spines of such slight development that they are hardly distinguishable by the naked eye. The mean diameter of the hair is the smallest.

Groups II and III comprise specimens provided with pelage possessing characters intermediate between those of the above quoted extreme groups. Of the groups, however, the former (Gr. II) is rather more similar to Group I than to Group IV, the latter (Gr. III) being reversed, as regards the various cited characters of the pelage. In other words, the specimens of Group III have somewhat coarser and

looser pelage with slightly more developed and thicker spines as well thicker hairs than Group II.

The maximum diameters of the spine and of the underfur hair of twenty pelages for every group respectively were measured, their mean values being given below:

Group	Number of hairs measured	Spine	Underfur
I	90—100	74,7±0,85 μ	29,3±0,66 μ
II	100	86,3±0,74 „	31,6±0,61 „
III	99—100	102,2±0,93 „	34,5±0,72 „
IV	100	121,9±1,11 „	36,1±0,77 „

Note:—Five hairs were measured for every pelage.

The mean lengths for every group are not to be always significantly distinguished from each another, nevertheless they are progressively magnified along with increasing grade of coarseness of the pelage, especially to a marked degree in the case of the spine. At any rate it is permissible to state that the last group decidedly exceeds the first and that the other two lie between them as regards the diameter of the hair.

The frequency distribution of the specimens belonging to every group was made for each month of the year in Table 1, so as to obtain some knowledge of the interrelationship between the coarseness of the pelage and the seasons.

TABLE 1.

Interrelationship between the coarseness of the pelage and the months of the year. The degree of coarseness progressively improves from Group I to IV. The mode of frequency is marked.

	Total	17	22	15	5	13	23	34	29	39	40	35	30	302
Male	IV	1	1	2	**3**	**9**	**12**	**25**	**17**	**13**	4	2	2	
	III	6	8	**7, 5**	1	4	9	8	10	12	**15**	12	12	
	II	**7**	**10, 5**	3	1		1	1	2	**13**	14	**19**	**16**	
	I	3	2, 5	2, 5			1			1	7	2		
		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	

	Total	24	15	21	8	9	7	20	24	30	32	35	18	243
Female	IV	1		3		2	3	3	3	5	4	2	1	
	III	4	2	7	2	5	3	12	15	11	7	9	5	
	II	16	9,5	9	6	2		3	6	11	16	19	10	
	I	3	3,5	2			1	2		3	5	5	2	
		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb	

It can be seen from Table 1 that the mode of frequency is mainly located in the line corresponding to Group IV (for the male) or III (for the female) from June or July to October, while it chiefly corresponds to Group II for both sexes from December or January to the following April. That is to say, this rat, in general, is possessed of relatively coarser pelage with more developed spines as well as thicker underfur hairs during earlier period, while the pelage becomes relatively softer, consisting of thinner hairs and spines during the later period.

Furthermore, we are led to percieve that the male generally tends to take precedence over the female in the coarseness of the pelage and the development of the spine throughout the year, especially so from June to October.

b) Length of the underfur.

The average length of the underfur has been measured near the center of the dorsum of the adult pelage by means of the following method. The vernier caliper is interposed into the underfur until the tip of its hand reaches the base of the fur and the distance (Fig. 1, PQ) between the base and the approximately average position of the tips of the underfurs, marked by P and Q respectively in Fig. 1, is measured. Two values in the different places were read and averaged for each individual. The mean values thus obtained were averaged for the specimens collected during the same month of the year (Table 2).

TABLE 2.

Mean value of the average underfur length on the dorsum of the adult pelage and the number of cases for every month.

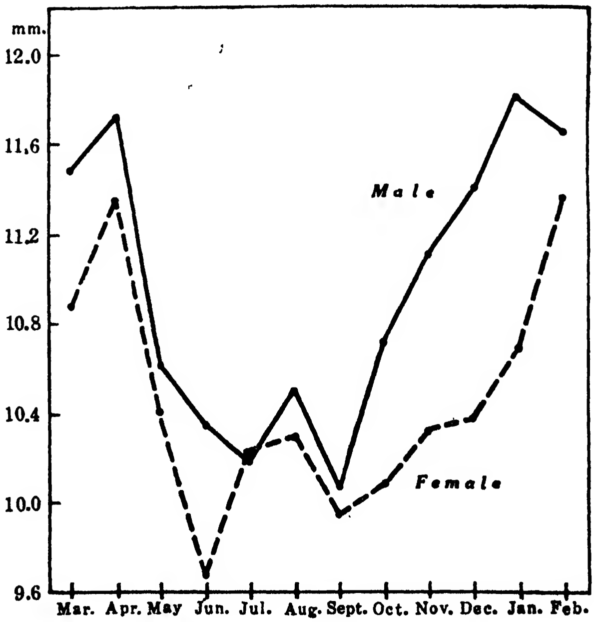
		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
Male	Mean (mm.) . .	11,5	11,7	10,6	10,4	10,2	10,5	10,1	10,7	11,1	11,4	11,8	11,7	Tolal
	Number of cases	17	22	14	5	14	22	34	29	39	41	35	29	301
Female	Mean (mm.) . .	10,9	11,4	10,4	9,7	10,2	10,3	10,0	10,1	10,3	10,4	10,7	11,3	Total
	Number of cases	24	15	22	8	9	8	20	24	30	30	35	19	244

The seasonal changes in the average length of the underfur on the dorsum is shown in Fig. 2.

We can easily see from this figure that the underfur length becomes most reduced (10,1—10,5 mm.) between June and September and increases most (11,5—11,8 mm.) between January and April for males, likewise it decreases most (9,7—10,3 mm.) between June and October and increases (10,9—11,4 mm.) between February and April for females. Accordingly there is a seasonal difference of 1,1—1,4 mm. between extreme values for summer and winter pelage, the value of the male being nearly always superior to

Figure 2.

Seasonal change in the average length of the underfur on the dorsum of the adult pelage. The ordinate indicates the mean values for the specimens collected during the same month. The solid line for male, the broken line for females.



that of the female in length throughout the year, the sexual difference averaging 0,57 mm.

c) *Coloration of the pelage.*

The seasonal variation in the general dorsal coloration of the adult pelage is shown in Table 3 a.

TABLE 3 a.

Frequency table indicating the relation between general dorsal coloration and the months of the year. The mode of frequency is marked.

		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
Male	Total	18	20	15	5	13	22	35	31	38	40	35	30	302
	Cinnamon, Russet, Isabela Color	1	1,5	0,5			0,5	0,5	1,5	0,5	0,5	1	1,5	
	dark Ochraceous . . .	13	15,5	12	4	11	16,5	29,5	24,5	27,5	29	25	19,5	
	dark Ochraceous Buff .	2	3	0,5		2	2,5	3	5	9,5	5,5	7	5	
	dark Buff										1		0,5	
	dark Wood Brown . .	1		1	1		1	1		0,5	4	1	1,5	
	Hair Brown, Olive . .	1		1			1,5	1				1	1	
Female	Total	23	15	22	8	10	9	20	25	29	31	35	19	246
	Cinnamon, Russet, Isabela Color	1,5	1	0,5		1			1	1	0,5	1,5		
	dark Ochraceous . . .	16,5	7,5	17,5	2	7	3,5	14	19	19	20,5	23,5	13	
	dark Ochraceous Buff .	4	5	1,5	1,5	1	4	6	3	6,5	5,5	7,5	4	
	dark Buff													
	dark Wood Brown . .	1		2,5	3	1				1,5	0,5	1,5	2	
	Hair Brown, Olive . . .		1,5		1,5		1,5		2	1	4	1		

It will be seen from this table that the general dorsal coloration is almost invariable with the season, being mostly dark Ochraceous, sometimes dark Ochraceous Buff and rarely Wood Brown, Hair Brown or Olive etc.

As previously noted, the pelage color is determined as compared

with RIDGWAY's color standard, the nomenclature of which is given to the group of specimens of the same color in this table. In general, however, the pelage in the specimen consisting of hairs of various kinds of color (*e. g. Rattus*) is of such a complex tint, that it is impossible to describe it easily. On this account the determination of the color according to the color standard is inclined to be made considerably approximate.

The colorimetric analysis by means of the IVES Tint-Photometer has been carried out in the dorsal side of the pelage of some individuals belonging to every color group in the table, in order to see the approximate tendency of the comparative quantitative color characters among these groups. The method of analysis is nearly the same as that of SUMNER ('27), differing only in that the photemeter is of a revised type and that the stuffed form of the pelage under observation is kept as it is. The mean and variation range of the observed value* for red (R), green (G) and blue violet (V) as well those for the index of saturation $\left(\frac{R-V}{R}\right)$ calculated from their individual values are shown in table 3 b.

TABLE 3b.

Colorimetric analysis by IVES Tint-Photometer of the dorsal shade of the pelage.

Color group	Number of observed specimens.	R	G	V	$\frac{R-V}{R}$
Cinnamon	4	10,1 (10,5-10,0)	7,9 (8,0-7,5)	6,8 (7,0-6,5)	33,3 (35,0-30,0)
Russet	7	9,1 (10,0-8,0)	6,9 (7,5-6,0)	6,2 (7,0-5,5)	31,9 (36,8-27,8)
Isabela Color	1	8,5	7,5	6,5	23,5
dark Ochraceous . .	9	10,3 (12,0-9,0)	7,9 (10,0-7,0)	6,9 (8,5-5,5)	32,6 (45,5-16,7)
dark Ochraceous Buff	8	9,4 (11,0-8,0)	7,7 (9,0-7,0)	6,9 (8,0-6,0)	27,1 (31,6-21,1)
dark Buff	2	8,8 (9,0-8,5)	7,8 (8,0-7,5)	6,3 (6,5-6,0)	28,6 (29,4-27,8)
dark Wood Brown .	7	9,3 (10,5-8,5)	7,6 (8,5-6,5)	7,0 (7,5-6,0)	24,5 (29,4-17,6)
Hair Brown	7	8,0 (9,0-7,0)	6,9 (7,0-6,5)	6,4 (7,0-6,0)	20,2 (33,3-12,5)
Olive	2	7,5 (8,0-7,0)	6,8 (7,0-6,5)	6,0 (6,5-5,5)	20,1 (21,4-18,8)

* According to SUMNER ('27), observed values should be assumed as slightly lower than the true on account of using the cover glass (No. 1).

From this table it can be seen that the two groups of dark Ochraceous and dark Ochraceous Buff, which include a large majority of all the specimens in this study, may be arranged in this order:

dark Ochraceous > dark Ochraceous Buff

for the values of red (R) and the index of saturation. As regards these values, the Cinnamon group is similar to the dark Ochraceous group, while the groups of dark Wood Brown, Russet and dark Buff are approximately near to that of dark Ochraceous Buff. The groups of Hair Brown and Olive are found to be to a relatively higher degree devoid of red tint and lack its saturation degree.

The general gray shade and the suffused yellowish and whitish tinge in the ventral side of the adult pelage are related with the seasons as shown in Table 4 and 5 respectively.

TABLE 4.

Frequency table showing the relation between the ventral general gray shade and the months of the year. The mode of frequency is marked.

		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	
Male	Total	17	19	15	5	13	24	31	29	37	41	35	29	298
	Gray 10 . . .			1	1		4	2		1, 5	1, 5			
	Gray 9 . . .	7	8	8	3	10	17	27	18	25, 5	33, 5	28	22	
	Gray 8 . . .	6	9	3	1	3	3	4	9	8	5	5	6	
	Gray 7 . . .	3	2	2				1	2	2	1	2	1	
	Gray 6 . . .	1		1										
Female	Total	24	9	20	7	9	8	19	25	28	29	33	18	229
	Gray 10 . . .				0, 5			2	1			0, 5	0, 5	
	Gray 9 . . .	16	5	16	4, 5	6	6	12	14	16	18	22, 5	9, 5	
	Gray 8 . . .	7	3	2	2	3	2	4	9	7	9	9	5	
	Gray 7 . . .		1	2				1	1	5	2	1	3	
	Gray 6 . . .	1												

TABLE 5.

Frequency table showing the relation between the suffused yllowish and whitish tinges on the ventral gray shade and the months of the year. The mode of frequency is marked.

		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
Male	Total	17	19	15	5	13	23	34	27	39	40	35	29	296
	yellowish quite or nearly absent (mostly with whitish)	3		1		1	5	3	3	3	5		1	
	whitish Cream Buff . . .								1				1	
	pale Cream Buff										1			
	Cream Color						1		1	1			2, 5	
	pale Cream Color	2	2	2	1		2	3	1, 5	2		3	3	
	whitish Cream Color . .	5	7	6	3	4	3	9	5	6	9	4	9	
	Straw Yellow	1						1	1	1	2	3	1, 5	
	whitish Straw Yellow . .											1		
	Primose Yellow	4	4		1	2		2	5, 5	7	10, 5	13	2	
	pale Primose Yellow . .						1	1	1	2	2		1	
	whitish Primose Yellow .	2	6	6		6	11	15	10	17	11, 5	11	8	
Female	Total	24	10	20	7	9	8	20	24	30	28	31	18	229
	yellowish quite or nearly absent (mostly with whitish)	2	3	1	1	1	1	2	4	2	1	5	1	
	whitish Cream Buff . . .													
	pale Cream Buff							1		1		1	1	
	Cream Color	1		1, 5				1	1	2	1	1, 5	1	
	pale Cream Color	3	1	5	2	1		3	3	3	3	3	3	
	whitish Cream Color . .	5	2	4	1	4	1	4	5	2	7	6	4	
	Straw Yellow	1, 5	1, 5	0, 5				1		1, 5	1, 5	1		
	whitish Straw Yellow . .													
	Primose Yellow	4, 5	0, 5	2	1		1		2	5, 5	6, 5	5, 5	2	
	pale Primose Yellow . .	1			1					4	1	2		
	whitish Primose Yellow .	6	2	6	1	3	5	8	9	9	7	6	6	

From the above it will be recognised that neither the general gray

shade nor the suffused yellowish and whitish tinge present remarkable seasonal change, because they are subject approximately to the same individual variation in every month as when they are treated together independently of the season. Namely, the general gray shade is for the major part Gray 9, sometimes Gray 8, rarely Gray 7 or Gray 10, all the year round, except that Gray 8 is relatively frequent in March and April for males, which might perhaps be accidental. The yellowish tinge is most often Cream Color and Primose Yellow, rarely Cream Buff or Straw Yellow, with, in many cases, a greater or lesser degree of whitish tinge added. The yellowish tinge may occasionally be absent. We should, however, pay attention to the tendency for whitish Primose Yellow to be decidedly predominant as compared to whitish Cream Color in the frequency between August and November for both sexes, which would seem to be somewhat significant.

IV. Differentiation between the summer and winter coat and the moult.

The foregoing quantitative analysis of the various characters of the adult skins resulted in the following findings with regard to seasonal variations:

(1) The pelage becomes relatively coarser and looser, bearing more developed spines and thicker underfur hairs from June or July to October while the condition is reversed from December or January to the following April.

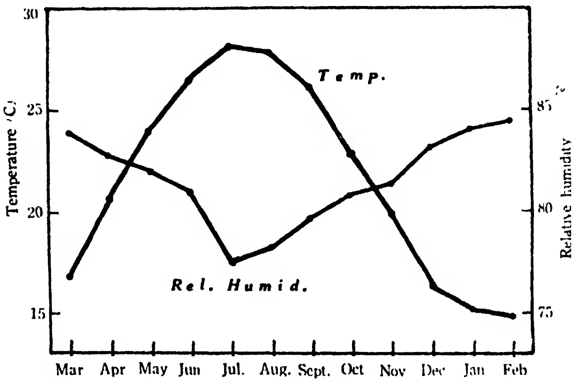
(2) The underfur on the dorsum keeps a minimum mean length from June to September or October and a maximum one from January or February to the following April.

(3) The pelage colorations show, roughly speaking, no remarkable seasonal variation, nevertheless some tendency towards a ventral yellowish tinge occurring from August to November would be noted.

The climatic conditions in the City of Taihoku are shown in Fig. 3, representing that the seasonal difference between winter and summer temperature amounts only to 13° while the relative humidity changes approximately being the reverse with temperature, showing readings above or below the value of 80%. The temperature remains the highest readings (about 26°–28°) from June to September, attaining the maximum in July, while the lowest ones (about 15°–17°) from December to March, the minimum being in February.

Figure 3.

Monthly mean temperature and relative humidity (Taihoku, Years 1897 to 1936, Taihoku Meteorological Observatory).



Therefore, generally speaking, it may be supported that in the present rat the existence of the summer coat can be ascertained approximately from the beginning of summer to the middle of autumn, when the temperature is highest and beginning somewhat to fall, while that of the winter coat is roughly from the middel of winter to that of spring, at which time the temperature is lowest and beginning slightly to rise.

How does the moult occur? Every pelage was scrupulously examined to see whether moulting was in progress. Evidence of the moult has been for the most part shown due to discovering areas of new hairs coming through the skin, which occur sporadically or continuously on the surface of the pelage. The total number of adult skins examined and the percentage frequency of ones with evidences of moult for each month of the year are shown in Table 6 and the seasonal change of the frequency in Figure 4.

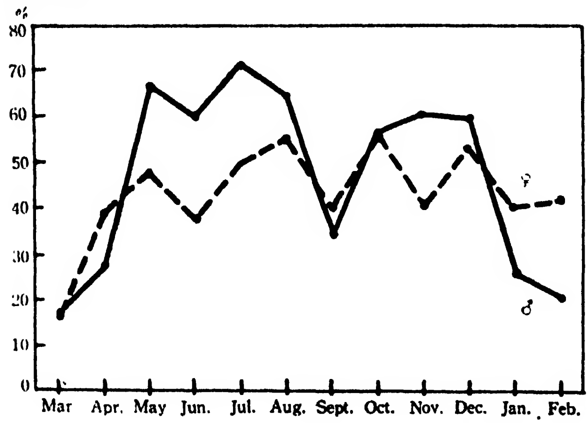
TABLE 6.

Percentage frequency of the adult skins with evidences of moult.

Male	Evidence of moult . .	3	6	10	3	10	16	12	17	23	25	9	6	Σ
	Total number of skins examined.	18	22	15	5	14	25	35	30	38	42	35	29	308
	Percentage of skins showing moult.	16, 7	27, 3	66, 7	60, 0	71, 4	64, 0	34, 3	56, 7	60, 5	59, 5	25, 7	20, 7	
Female	Evidence of moult . .	4	7	11	3	5	5	8	14	12	17	14	8	Σ
	Total number of skins examined.	26	18	23	8	10	9	20	25	30	32	35	19	255
	Percentage of skins showing moult.	15, 4	38, 9	47, 8	37, 5	50, 0	55, 6	40, 0	56, 0	40, 0	53, 1	40, 0	42, 1	
		Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	

Figure 4.

The ordinates indicate the percentage of the number of skins with evidences of moult for each month of the year. Solid line for males, broken line for females.



According to Fig. 4, the female remains nearly the same frequency value of 40–55% in the moult all the year round except for January, while the male exihibits higher values of 60–70% from May to December except for September and lower values of 15–30% from January to the following April. The maximum value is attained in July.

If we consider altogether the cases in both sexes, it can be stated that the lower frequency of moult generally tends to occur during the period of lower temperature and *vice versa*. There seems to be no marked evidence displaying the existence of an autumnal or vernal

moult correlated with the differentiation between summer and winter coats. This will be further discussed in the last section.

V. Discussion.

As described above, the skin of *Rattus losea* is as a rule provided with two kinds of overhairs, a spine and a longer but finer black hair. According to ABE ('34), the spines of the Amami spinous rat correspond to the " Mittelhaare " in MEIJERÉ's terminology (1894), and in some hair groups the " Mittelhaar " is an overhair. If the spine of *Rattus losea* is the " Mittelhaar " of the hair group, as in the spinous rat, it seems open to doubt whether the second overhair, longer but finer than the spine, should correspond to " Mittelhaar " or to " Seitenhaar."

From the examination of the spiny or other rat group in India and Formosa, THOMAS (1881) concluded that the presence of spines in the skin far from being a generic or subgeneric character, is not even of specific importance. He is inclined to think that in all tropical countries a development of spines takes place in summer, these fall off again in winter. According to him, spines are presumably a much cooler covering than hair, as all of the numerous spiny rodents known are inhabitants of tropical or subtropical countries.

These views on the development of the spines will be made ascertained from the findings concerning our rat, which is considered a non-spiny rat in the subtropical region.

There is much controversy concering the winter-white mammals, such as hares and stoats, with regard to the processes of vernal and autumnal coat changes. BARRET-HAMILTON ('10-'16, vol. II, p. 302) concluded that all modern observers are in agreement that the autumnal bleaching is still variously attributed to moult or to actual abstraction of pigment from hairs.

As a result of a direct observation of living and dead hares, as well of a stoat, USHER was led to conclude (PEARSON and others '13)

that he is unable either macro- or microscopically to detect any evidence either of the appearance of pigment in the white hairs, or of bleaching of the colored coat.

ABE ('30), in a histological study of the summer and winter coat of the Etigo snow hare and of several other Japanese mammals showing no winter-whitening, found that the winter hair is not only longer but of quite different structure from the summer hair, so that he maintains that the winter and summer hair are quite distinct also in the majority of wild animals, *i. e.*, a main coat change takes place twice a year.

The statistical evidence as regards the seasonal variation either in the mean length of the underfur or in the mean value of the diameter of the dorsal hairs of our wild rat will lend some support to ABE's view that the winter hair is one thing and the summer one is another.

The seasonal variation in the pelage of some British murine forms are described by BARRET-HAMILTON. For instance, the water rat shows two irregular moults, the summer coat being shorter and often redder, owing to the absence of the long hairs with dark tips (vol. II, p. 480). According to HATT ('29) the winter pelage of the red squirrel is thicker, longer and softer than that of the summer one and its typical summer coloration is very red and the lateral line very black, while in its typical winter coat the broad rufous dorsal band is most distinct and the black lateral line least so.

At present, however, no generalised features on the seasonal change of the coat color have as yet been encountered at least in the literature of murine rodents so far as we are aware, but the inclination of the summer coat to be coarser, thinner and shorter than the winter one should be commonly accepted.

It is to be noticed that non-occurrence of apparent seasonal variations of the coat color, regardless of the decided evidence presented by other coat characters, has been shown in the present rat.

COLLINS ('23) investigated the seasonal moults in a deer mouse either by observing the skins of animals in captivity or by inspecting a series of nearly two hundred skins of adults, in which every month

of the year is represented. According to him, some change of pelage may be under way at any month of the year, a maximum being reached during September and October *i. e.*, the period of the autumnal moult, but there is no apparent evidence of spring moult, as in most of the species *Peromyscus*.

As previously shown, the evidence of the moult in the present rat does not indicate a remarkable frequency either during the months of spring or during those of autumn, on the contrary even with the reversed tendency in September for males, indeed, approximately speaking, this frequency tends to fall slightly more in colder seasons than in others.

Although it would appear most probable that a chief coat change twice a year takes place in mammals showing apparent seasonal variation in the pelage, we can see that the same is not always the case in all instances, *e. g.* the deer mouse just quoted, in which a marked frequency is found only in the case of the autumnal moult. In contrast with this, we are unable to point out any main coat change, not only vernal but also autumnal, from the date of our rat. Accordingly, in so far as the evidences for moult we have are concerned, we are inclined to the view that the moulting process may be to a greater or lesser degree always conducted during any month of the year.

The different types of moult have been indicated in allied groups of some mammals, for instance the generic differences in the moults of moles (JACKSON '15), the peculiarities of moulting in different groups of American rabbits (NELSON '09), and in *Peromyscus* (OSGOOD '09). The different manner in which the postjuvenal pelage is assumed by several species of *Peromyscus* is pointed out by COLLINS ('23).

In our wild rat, the condition of the seasonal change of the sizes of the spine and the underfur hair might well be partially referable to environmental agents, in other words, it would be a general inclination of inhabitants living in a subtropical climate. Nevertheless, it cannot be determined whether the types of the seasonal change in coat-color and the moulting process should be ascribed to environ-

mental or to racial agents, until a comparative investigation is made among Formosan murine forms.

At any rate, the manner already referred to in which some pelage characters of this species is subject to seasonal variation and the condition of the moult, teach us to some degree the scope of the effects of the seasonal agent upon the variation in the specific characters due to various kinds of causes.

VI. Summary.

(1) A series of nearly five hundred adult skins were examined to determine the manner of the seasonal variation in the coat characters of *Rattus losea* (SWINHOE, 1870), collected from the Basin of Taihoku in the northern part of Formosa.

(2) A summer pelage may be distiguished from a winter one by the fact that, in summer, the skin is found to be generally cearser and looser, consisting of more developed spines and thicker but shorter hairs of the underfur, while in winter the tendency is reversed.

The pelage coloration, however, shows no significant seasonal variation, except for some tendency towards a ventral yellowish tinge occurring from August to November.

(3) Sexual difference may be more or less seen in the coarseness of the pelage as well as in the mean length of the underfur on the dorsum.

(4) In so far as the present material goes, the coat change occurs to a greater or lesser degree at any month of the year, indicating no remarkable autumnal or vernal moult, but it appears to occur more infrequently during colder seasons.

(5) Although it is still completely unknown to what degree the manner of the seasonal variation and the moult in the pelage of this rat should be referred to climatic or racial factors, these will more or less evidence an influence of the seasonal agent upon the variation of the specific characters.

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HEMERYTHRIN FOUND IN THE BLOOD OF *LINGULA*

Siro KAWAGUTI

(Accepted for publication, Oct. 25, 1940)

The blood of *Lingula*, turns reddish-purple when brought into contact with the air, and becomes colourless again under decreased oxygen tension. This suggests a change of the pigment through oxygenation.

The blood of *Lingula unguis* L.[1][2] is collected by opening the pallial sinus and squeezing the shell gently. The supernatant plasma obtained when the blood is centrifuged, is colourless or slightly yellowish, and the sediment contains blood corpuscles of spherical or somewhat irregular shape, leucocytes and so-called spindle bodies.[3] Only the blood corpuscles have red pigment, as reported by FRANCOIS,[4] while the other two members of the blood seem to have no pigment. The sediment is washed with artificial sea water several times, and is laked with distilled water. Then it is again centrifuged and the supernatant part only used for the test.

This solution gives white precipitates with HCl, while turns colourless with NaOH. Such decolorations seem to be in correlation with the denaturation of the pigment. Effects of pH are shown in the following table. A definite amount—say, five drops—of the pigment solution is added to 10 cc of buffer solutions.

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1) The material used was collected at Tainan in April of 1936, by courtesy of the Tainan Branch of Fisheries Experiment Station of the Formosan Government.
2) HAYASAKA, I., 1932. Science Rep. Tohoku Imp. Univ. 7, 11–13.
3) YATSU, N., 1902. Jour. Coll. Science Tokyo Imp. Univ. 17, Art. 5, 1–29.
4) FRANCOIS, PH., 1891. Arch. Zool. Exp. et Gen. 19, 231.

pH	*Nature of Buffers*	*Decoloration time*
10	Boric-KCl-NaOH	Instantaneous, irreversible
9	"	40 minutes, irrev.
8	Phosphate	Over 12 hours, reversible
7	"	Over 12 hours, rev.
6	"	70 min. rev.
5	Acetic-acetate	10 min. irrev.
4	"	Instantaneous, irrev.

The pigment is stable only within a limited range of pH which is shifted toward the alkaline side in consistency with the pH of sea water.

The pigment solution has a strong Prussian blue reaction showing the presence of iron, but no reaction for copper. When K-ferricyanide is added to the reduced pigment solution with $Na_2S_2O_4$, the blue precipitate appears. This colour reaction is reversible by oxidation and reduction.

Spectroscopic study of the pigment solution gives the following results. The oxygenated pigment affords an obscure band at the range of 520–470 mμ. The general features of the spectrograms are almost similar to those given by ROCHE[5] for the hemerythrin of *Sipunculus nudus.*

By reason of these characteristics, the pigment may be identified as hemerythrin, reported in *Sipunculus* and *Phascolosoma* by ROCHE,[5] FLORKIN[6] and MARRIAN.[7]

OHUYE[8] reported that the blood pigment of *Lingula* may be identified with hemoglobin and it is crystallized within the cells by gentle withdrawal of water. Similar figures[9] are observed also in my preparation on the slide-glass but they disappear under crossed

5) ROCHE, J., 1933. Comp. Rend. Soc. Biol. 112, 251–4, 683–5.
6) FLORKIN, M., 1932. Comp. Rend. Soc. Biol. 111, 1059-61.
7) MARRIAN, G. F., 1927. Jour. Exp. Biol. 4, 357–364.
8) OHUYE, T., 1937. Science Rep. Tohoku Imp. Univ. 12, 243-5.
9) For this section the material was supplied in October, 1939, from Yanagawa on the Bay of Ariake, Kyusyu.

Nicol's prisms. Any other crystals appearing in the sea-water and the dye solution could be seen by careful observations under crossed Nicol. No characteristic absorption band for hemoglobin could be observed. Hence, OHUYE's conclusion for the blood pigment of *Lingula* is open to criticism.

As a test for the respiratory function of this pigment, the oxygen dissociation curve is examined colorimetrically. The pigment solution is divided into two Baly tubes (as is described elsewhere[10]) one for standardization and the other for test. The thickness of the standard solution which corresponds to the test solution in colour is measured. 50% and the 100% saturations are reached at about 16 mm and 60 mm Hg of oxygen partial pressure, respectively. This being rather a high value, the pigment seems to have very low ability for taking up oxygen from the outer medium.

TANAHASHI[11] reported that the oxygen capacity of the blood of *Lingula* was 4.63–5.78 in volume percentage and that the oxygen dissociation curve was approximate to a rectangular hyperbola.

The pigment solution reduced by $Na_2S_2O_4$ restores the original red colour by reoxygenation with air or H_2O_2, this never occurs with K-ferricyanide. Thus it may be said that the only way to form coloured pigment is oxygenation.

The redox-potential of the half-reduced pigment solution shows $E_0'=0.460$ volt at pH 6.80, 21°C. E_0' is obtained from the titration curves with $Na_2S_2O_4$ and H_2O_2. This is rather high value for the biological redox-system. Such a high value is observed also in hemocyanin,[12] $E_0'=0.540$ at pH 7.

The colour is reduced completely at 0.27 volt under the same conditions. The reduction potential of tissue "brei" of *Lingula* is 0.24 volt at pH 6.8. These data show that the pigment of *Lingula* is very easily reduced, that is, the oxygen carried by the blood may

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10) KAWAGUTI, S., 1936. Memoirs Fac. Science & Agr. Taihoku Imp. Univ. 14, 91-115.

11) TANAHASHI, Y., 1938. Nihon Seiri. Z., 3, 139.

12) Tabulae biologicae 10, 1.

be taken up easily by the tissue. The tissue also has a high redox-potential in consistency with the pigment.

Summary

Red blood cells of *Lingula* contain hemerythrin, which is reduced very easily to a colourless form, regains the reddish-purple colour by oxygenation. The nature of the pigment is almost identical with that of hemerythrin from *Sipunculus* and *Phascolosoma*.

The redox-potential of half-reduced hemerythrin of *Lingula* is $E'_0=0.460$ volt at pH 6.8, 21°C.

It is interesting to note that the hemerythrin has been found previously in several gephyrean worms such as *Sipunculus*, *Phascolosoma*, *Physcosoma* and also in an annelid *Magelona* and now in a brachiopod.

ELECTROLYTES IN PARAMECIUM[1]

Yasu Kazu AKITA

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During the past two or three decades, the ionic make-up and ionic permeability of blood cells, muscles, nerves and large plant cells have been revealed by many investigators (e.g. HENDERSON, VAN SLYKE, JACOBS, FENN and OSTERHOUT). As to the Protozoan cells, however, our knowledge in this direction remains very imperfect. The following experiments were undertaken as a contribution to this subject.

The greater part of this work was done while the author was in the Zoological Laboratory, Faculty of Science, Tokyo Imperial University, from 1935 to 1939. It is a pleasure to acknowledge my indebtedness to Prof. N. YATSU and Dr. T. KAMADA who suggested this problem to me and assisted me with criticism throughout the progress of the work. Grateful acknowledgement is also made to Prof. K. HIRASAKA of this university who kindly afforded me every facility to continue the work in his laboratory.

Material and Method

The material used was *Paramecium caudatum*. In a large basin of about 10–15 litres, meadow hay (mainly of timothy) was loosely placed with hot water extract of soil (obtained by boiling 250 gm. soil with 1 litre tap water) and tap water was added to cover the hay. After two week's standing it was inoculated with Paramecia. Within a week or two, a thick suspension of the organism could be obtained from it. The multiplication of the organism continued for

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1) Aided by the grants from the Imperial Academy.

over two months in this medium, when about half a litre of water and a small amount of hay were added to the culture at an interval of two or three days.

The culture fluid with crowded organisms was passed through a sheet of Victoria lawn in order to remove the debris. The fluid thus obtained was poured into a long-necked flask of approximately 1 litre capacity up to the lower end of the neck, and tap water was then added carefully to it to fill the neck part of the flask without much contamination with the fluid. When Paramecia aggregated densely at the top of the layer of tap water by their negative geotaxis, they were transferred into a glass beaker and the neck part was again filled with tap water. This process was repeated, usually three or four times, until most of Paramecia in the flask were collected. The preparation of Paramecia obtained by this procedure was filtered through a silk gauze mounted on a Buchner's funnel. The silk gauze was so selected that its texture was just enough to retain Paramecium but not other smaller organisms found in the preparation. On this silk gauze Paramecia were washed thoroughly with the experimental solution to be used. Then they were dispersed in the experimental solution at a density of about 10^5 cells per litre. After standing at 25°C. for 22–24 hours, they were analyzed for their electrolyte contents.

The determinations of potassium, sodium and calcium were made as follows: Paramecia which had been suspended in the experimental solution, were again collected on the silk gauze and condensed further in a special type of centrifuge tube which had a graduated constriction near its bottom. After decanting the supernatant fluid,[2)] the cells were washed once with about 10 cc. of redistilled water (buffered to be pH=7.3 by bicarbonate solution whose cationic constitution was so adjusted as practically not to affect the analytical data in question). The preparation was centrifuged again, and the supernatant fluid with Paramecia above the constriction was removed with a pipette. The

2) The experimental procedure up to this stage was common to that for the determination of chloride content.

condensed mass of Paramecia,[3] the volume of which was read off by the graduation of the tube, was transferred to a Pyrex crucible with a small amount of distilled water. The crucible was heated in an oven at 100–110°C. for more than 6 hours, and then the determination of the dry weight was made.

To the dried preparation, 5 cc. of 50% nitric acid and 0.5 cc. of 50% sulphuric acid were added. After standing overnight (at room temperature), the contents of the bottle were digested on a steam bath until the main part of it became a homogeneous yellowish solution with a small amount of undissolved substances floating on the surface. The yellow solution with the floating material was transferred to a platinum crucible, evaporated to dryness on a hot plate and ashed overnight in an electric oven at 600–650°C. The ash was mixed up with 1 cc. of 1/10 N HCl. A small amount of distilled water was then added and the crucible was heated for several minutes over a steam bath. The volume of the solution was adjusted with distilled water to a definite value, and a known fraction of the solution was used for the analyses. Potassium was determined by the method of KRAMER and TISDALL (1921), sodium by the method of SALIT (1932) and calcium by the method of WANG (1935), the last two methods being employed with certain modifications.[4]

3) The condensed mass of Paramecia still contained a little solution in the space between the cells, and a small amount of the external electrolytes remained in it. However this may be corrected from the volume and the composition of the remaining solution. The former was obtained by the difference between the volume of the mass and the total cell volume which was calculated from the dry weight, employing the data presented by IIDA (1940 b). The latter was not measured, but calculated from the composition of the experimental solution and the chloride concentration of the supernatant fluid from the final washing, the chloride determination being made by the micro-VOLHARD method.

4) SALIT's method is based upon the precipitation of sodium as triple acetate with uranium and zinc. The amount of the precipitate was determined colorimetrically after dissolving it in distilled water and adding an appropriate amount of $K_4Fe(CN)_6$. A series of standard solutions was prepared with concentrations of sodium varing from 0.01M to 0.0005M and the sample to be determined was compared with the standard solution of close strength. The aqueous solution of the precipitate was brought up exactly to 25 cc. (or 10 cc., if the precipitate obtained is not much) in a volumetric flask.
In the determination of calcium, calcium oxalate was precipitated from a solution not containing any buffer other than ammonium oxalate that serves as a precipitating agent and the pH of the solution was adjusted to 5 by adding a proper amount of ammonia as recommended by ROBERTSON and WEBB (1939).

In the case of chloride determination, the initial steps of the procedure were the same as before. After the sedimentation of the cells by centrifuging and the removal of the supernatant fluid (cf. foot-note 2), the total cell volume was determined by the following procedure. Drops of the solution (if any) that clung to the wall of the tube, were wiped off with a strip of filter paper. The volume (a cc.) of the condensed suspension remaining in the tube was read off by the graduation of the tube. Exactly 5 cc. of the "washing solutian"[5] were added and mixed up thoroughly. The cells were again sedimented by centrifuging and the supernatant fluid was removed as quickly as possible, taking special care to avoid the removal of the ascending Paramecia at the same time as the fluid. Then the supernatant fluid was analyzed for chloride. Assuming that during the procedure no change in the cell volume occurs, and no chloride escapes from the cell, the total cell volume (V cc.) could be calculated according to the following equation;

$$V = a - \frac{5C_2}{C_1 - C_2}$$

where C_1 and C_2 represent the chloride concentration of the experimental solution and that of the supernatant fluid respectively.

The sedimented Paramecia in the above procedure were analyzed for chloride by the adsorption method of CONWAY (1935), with certain modifications concerning the method of cytolysis and protein precipitation. The procedures employed were as follows: The cells were washed twice with the washing solution to remove the chloride of the surrounding medium, but sometimes analysis was carried out without such washing.[6] The condensed organisms were cytolyzed by the method of freezing and thawing with a small quantity of dis-

5) The washing solution was made up by substituting the nitrate for the chloride of the solution in which Paramecia had been immersed before the analysis.

6) In this case the condensed suspension to be analyzed contained a minute quantity of chloride in the remaining solution. This quantity was calculated from the chloride concentration of the supernatant solution (C_2) and the volume occupied by the solution which was obtained by subtracting the total cell volume from the volume of the suspension to be analyzed.

tilled water added, but infrequently they were subjected to analysis without being cytolyzed. In order to precipitate the protein, 1 cc. of N/3 sulphuric acid and 0.5 cc. of 10% sodium tungstate were added and mixed thoroughly. The mixture was brought up to 5.0 cc.[7] with distilled water and transferred to a centrifuge tube. This tube was centrifuged along with a similar tube (for a blank determination) which contained no cellular substance but 3.5 cc. distilled water and the reagents added as before. 2.0 cc.[8] of the supernatant fluid were transferred to the outer chamber of an absorption apparatus containing about 0.2 g. of powdered potassium permanganate and 1 cc. of 20% potassium iodide in the central compartment. The determination was then made in the usual manner as described by CONWAY. The amount of iodine liberated in the central chamber was determined colorimetrically after adding a measured amount of 0.5% starch solution, the ordinary colorimetric method with standards being adopted.

In some cases, analysis was made by the open CARIUS method with a preliminary alkaline digestion of organic matter as recommended by SUNDERMAN and WILLIAMS (1933). On this occasion Paramecia condensed by centrifuging were transferred into a Pyrex crucible and dried over a steam bath. After adding 10 cc. of N KOH, the crucible was covered with a small watch glass and heated over a steam bath until the dried mass adhering to its wall was made to float on the surface of the solution. Then the contents were transferred into a 50 cc. Erlenmeyer flask and the digestion was carried on for more than 1 hour, after which the analysis was conducted following the method described by SUNDERMAN and WILLIAMS.

Potassium and Sodium

1) *Concentrations of Potassium and Sodium within the Cell vs. those of surrounding Medium.*

7) When the volume of Paramecia to be analyzed was roughly more than 0.4 cc., the mixture was brought up to 10 cc., instead of 5 cc., with distilled water.

8) On the occasion of using a comparative large amount of Paramecia, such as is described in foot-note 7, 5 cc. of the clear fluid was analyzed in a larger absorption apparatus (diameter: 7.5 cm.; height: 1.6 cm.).

In the first group of experiments, the potassium and sodium contents of Paramecium were determined after suspending the organisms in a mixture of required proportion of 0.01 M NaCl and 0.01 M KCl solution (buffered to pH=7.2-7.4 by $NaHCO_3$ and $KHCO_3$ respectively). Both of these two solutions contained 0.0007 M $CaCl_2$, since the mixture otherwise caused the death of Paramecia in the course of adaptation. Although the density of the organism was very low as is described above, the pH of the solution usually was decreased from

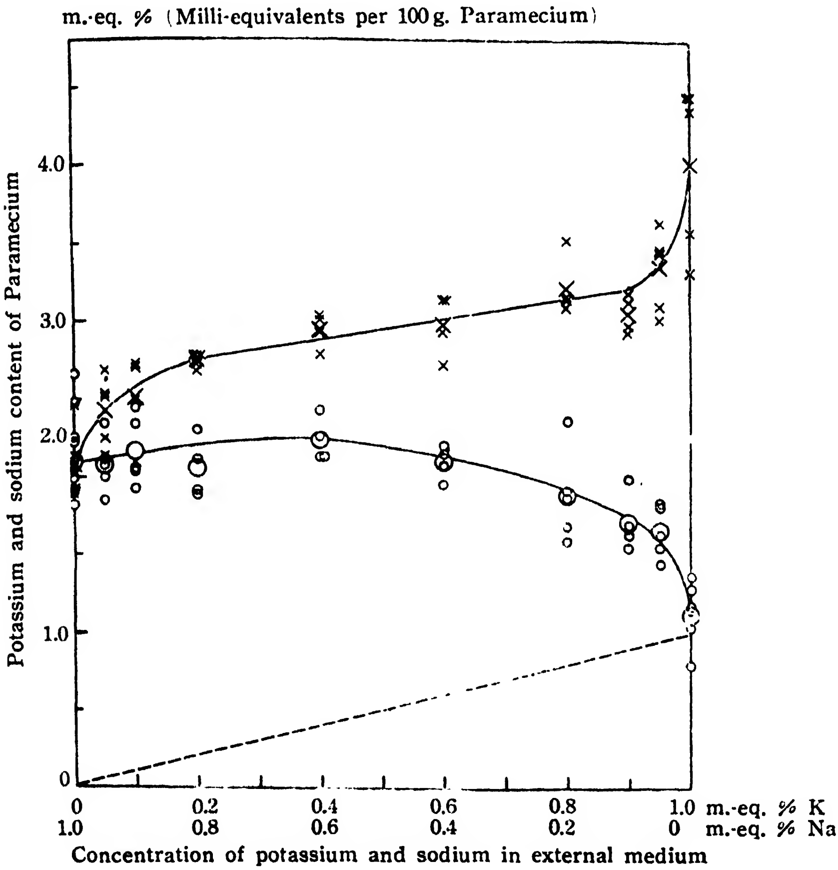

Fig. 1.

Potassium and sodium contents of Paramecium after immersing for 22-24 hours at 25°C. in a series of mixtures of NaCl and KCl. Potassium contents are indicated by crosses and sodium contents by circles. Small symbols represent single determinations and large ones average values.

7.2–7.4 to 6.1–6.4 within the adaptation time of 22–24 hours. But such a modification in the external pH seems to be practically negligible for the salt accumulation in question, as will be shown later. The results of these experiments are presented in figure 1. The potassium contents are represented by crosses and the sodium contents by circles. Each point, in smaller size, represents a single determination and that in larger size an average value, the curves being drawn tentatively to give an approximate fit. The concentrations are expressed in milli-equivalents per 100 g. of Paramecia or of solutions (m.-eq. %).[9] The dotted straight line shows the hypothetical amounts of intracellular potassium which would be expected if the concentration within the cell were equal to that without.

It is apparent from the figure, that sodium as well as potassium in Paramecium are present in higher concentration than in the surrounding medium, and that the salt contents are increased or decreased with the modification in its external concentration. In both cases there is no linear relationship between internal and external concentrations. When the potassium outside, K_o, becomes less than 0.2 m.-eq. %, the potassium inside, K_i, markedly decreases. But even in the sodium solution containing no potassium, a considerable amount of potassium is still retained within the cell. Some fraction at least of this potassium, however, can not be considered to be firmly "bound" within the cell, for the later experiment shows that more potassium can be lost in the sodium solution of higher concentration. In stronger solutions than 0.2 m.-eq.% K_o, K_i increases roughly in linear proportion with K_o, but a greater increase occurs when K_o exceeds 0.9 m.-eq. %. Perhaps the main feature of these changes might be accounted for by the ionic exchange of potassium and sodium across the cell membrane, which will be discussed later.

The sodium inside, Na_i, behaves somewhat in a different manner from K_i. The curve for sodium shows a maximum at about 0.6 m.-

9) The weight of Paramecium was also calculated from dry weight by employing IIDA's data (IIDA 1940b).

eq.% Na_o. At external concentration greater than this, there is no further increase in Na_i, but rather a slight decrease. In weaker solutions again Na_i decreases with the decrease of Na_o, and this decrease is nearly compensated by an increase in K_i, suggesting, as is pointed out already, that sodium diffuses out of the cells in exchange with external potassium. With higher Na_o values, however, the decreases in K_i are not exactly accompanied by the compensatory increases in Na_i, so that the total mols of (Na_i+K_i) somewhat decreases. These relationships are more clearly seen in figure 2, in which the values of (Na_i+K_i) are plotted against the composition of the external medium.

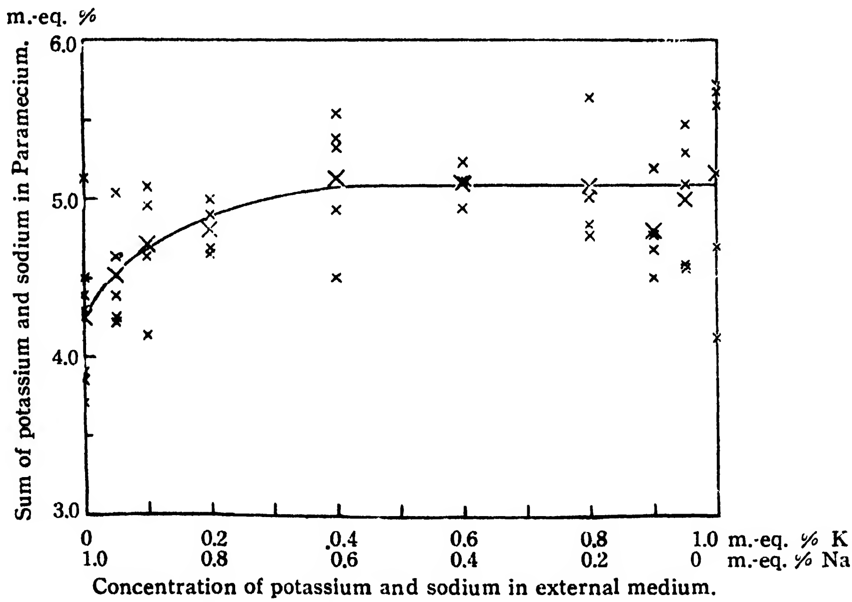

Fig. 2.

Sum of potassium and sodium within the cell under the same experimental conditions as Fig. 1. Small crosses represent individual determinations and large ones average values.

In addition to the above experiments, the potassium content of Paramecium was determined with similar sorts of mixture of Na and K but of three different osmolar concentrations. These solutions were prepared by mixing M/50, M/100, or M/500 sodium solutions

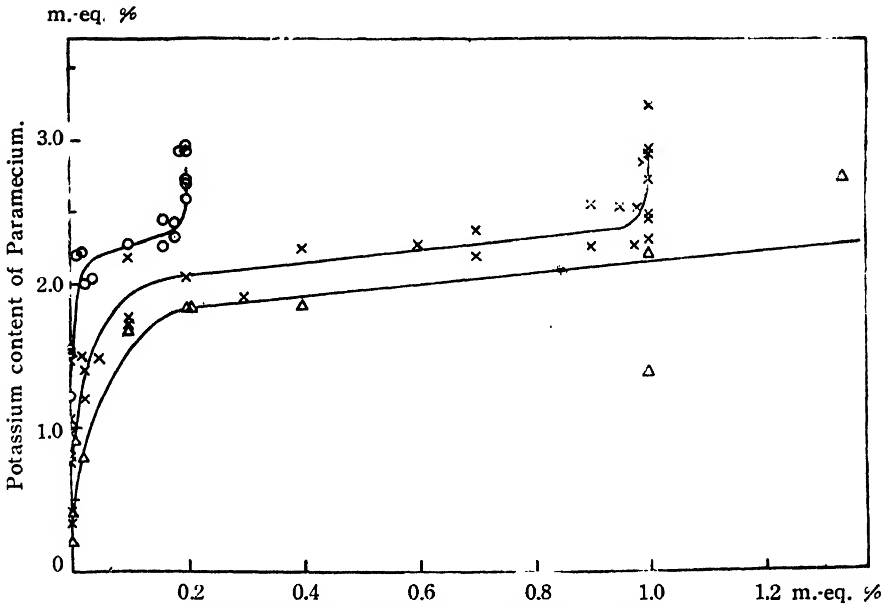

Fig. 3.

Potassium content of Paramecium after immersing for 22–24 hours at 25°C. in experimental solutions. The solutions were prepared by diluting M/50, M/100 and M/500 potassium solutions (pH=7.4 by K-phosphate) with isosmotic sodium solutions (pH=7.4 by Na-phosphate) respectively, so as to possess various concentrations of K ions at a given osmolar strength (M/50, M/100 or M/500). Data with M/50 solutions are represented by triangles, data with M/100 solutions by crosses, and data with M/500 solutions by circles.

with isotonic potassium solutions.[10] The results are shown in figure 3. Perhaps the most significant feature of the figure lies in the fact that, at the identical potassium concentration of the medium, different potassium contents are found in the cell if the osmolar concentration of the medium is different. The higher the total osmolar concentra-

10) All these solutions were buffered to pH=7.4 by a phosphate buffer and always contained $CaCl_2$ at the concentration of 0.0007M. For example, the actual composition of the M/100 sodium solution was as follows:

M/10	NaCl	80.0 cc.	
M/10	$CaCl_2$	7.0	
M/5	Na_2HPO_4	8.0	brought up to 1000 cc. with redistilled water.
M/5	NaH_2PO_4	2.0	

The potassium solution was prepared similarly with potassium (instead of sodium) phosphate buffer. In the M/500 solutions, only Na or K phosphate buffers were used with the $CaCl_2$ solution, and NaCl or KCl was not dissloved.

tion is, the lesser the content. Furthermore it is remarkable that the external concentrations at which these curves inflect, have an approximately similar ratio of Na and K. These results may suggest that during the penetration of potassium there is an ionic exchange of potassium for sodium. In order to make this suggestion more conclusive, it is necessary to ascertain whether or not the value (K_i + Na_i) is constant in all the experimental solutions. However, the determination of the sodium content has not yet been performed in these series of experiments.

2) *Effect of External pH*

JACQUES and OSTERHOUT (1933) have found that increasing pH of the surrounding sea water increases also the rate of entrance of potassium into *Valonia* cells. FENN and COBB (1934) also have shown that potassium equilibrium in muscle is greatly influenced by external pH. In order to see the effect of external pH in the case of Paramecium, the potassium and sodium contents of the cell were measured after suspending for one day in the experimental solutions of the same cationic composition but different pH.

The effect of external pH was tested in four experimental solutions, in which the potassium concentration was 0, 0.2, 0.8 and 1.0 m.-eq.% while the sodium concentration 1.0, 0.8, 0.2 and 0 m.-eq.% respectively.[11]

Paramecia, collected from the hay culture, were divided into two portions; one of them was suspended in the experimental solution of pH 7.4 and the other in the same sort of solution but of pH 5.9. After standing for 24 hours at 25°C. they were analyzed for their

11) The experimental solutions were prepared as follows;

		Sodium solution of pH 7.4	Sodium solution of pH 5.9
M/10	NaCl	64 cc.	78 cc.
M/10	$CaCl_2$	7	7
M/5	Na_2HPO_4	8	1
M/5	NaH_2PO_4	2	9

Both brought up to 1000 cc. with redistilled water.
The potassium solutions were made by substituting potassium salts for sodium salts in the above prescription. The pH 7.4 solution of 0.2 m.-eq. % Na and 0.8 m.-eq. % K, for instance, was obtained by mixing appropriately the two kinds of solution of the same pH.

TABLE 1.

Sodium and Potassium content of Paramecium after being suspended in experimental solutions of pH 7.4 and pH 5.9.
(Milli-equivalents per 100 grams of cell or solution)

Concentration of Na and K in solution		Sodium content		Difference	Potassium content		Difference
Na	K	at pH 7.4	at pH 5.9		at pH 7.4	at pH 5.9	
1.0	0.0	—	—	—	1.44	1.56	0.12
		0.90	0.67	−0.23	1.25	1.27	0.02
		1.61	0.95	−0.66	1.23	1.61	0.38
		1.14	0.91	−0.23	—	—	—
		1.58	1.90	0.32	2.50	2.07	−0.43
		1.95	1.07	−0.88	1.47	1.34	−0.13
		Mean 1.44	1.10	−0.34	1.58	1.57	−0.01
0.8	0.2	—	—	—	2.71	2.60	−0.11
		1.71	1.34	−0.37	—	—	—
		1.69	1.87	0.18	—	—	—
		—	—	—	2.29	2.58	0.29
		1.62	1.85	0.23	2.02	2.39	0.37
		1.82	1.81	−0.01	1.89	1.87	−0.02
		1.54	1.49	−0.05	2.18	2.10	−0.08
		Mean 1.68	1.68	0.00	2.22	2.31	0.09
0.2	0.8	1.86	1.66	−0.20	2.77	2.58	−0.19
0.0	1.0	—	—	—	3.02	3.34	0.32
		—	—	—	4.17	3.90	−0.27
		0.59	0.73	0.14	2.98	2.24	−0.74
		1.19	0.78	−0.41	2.90	2.43	−0.47
		1.21	1.40	0.19	2.68	2.73	0.05
		1.13	0.96	−0.17	3.15	2.35	−0.80
		0.40	0.44	−0.04	2.90	2.27	−0.63
		Mean 0.90	0.86	−0.06	3.11	2.75	−0.36

contents of potassium and sodium. The results are summarized in Table 1. It is apparent from the table, that the potassium and sodium content of Paramecium are hardly influenced by the change of external pH, although the potassium content of the cell kept in potassium solution, and the sodium content in the sodium solution are in most cases somewhat less at lower pH than at neutrality. In this respect, potassium in Paramecium behaves rather similarly to what it does in the nerve of frog (FENN and his coworkers, 1934 a) and in the fresh water alga *Nittela* (JACQUES and OSTERHOUT, 1935).

Chloride in Protoplasm

In the foregoing section, it has been shown that potassium and sodium in Paramecium are present in higher concentration than in the surrounding medium and that they probably constitute the main fraction of the intracellular cations. The question then arises; what are the anions which combine with potassium or sodium within the cell? On the other hand, the results of the above experiments suggest that potassium penetrates by an ionic exchange with sodium and vice versa, and hence it is considered that the cell wall is impermeable to anions. Although KAMADA's study (1934) on the electrical potential difference across the membrane of Paramecium may be taken to show that the membrane is more permeable to cations than anions, direct evidence of anion impermeability in Paramecium has not yet been offered. As a first step towards investigation on these questions, analyses of chloride in Paramecium were undertaken.

Paramecia, collected from the hay culture, were immersed in a solution of the following composition; 0.005 M NaCl, 0.005 M KCl, 0.0007 M $CaCl_2$ and 0.00024 M $NaHCO_3$ in 1 litre redistilled water. After standing at 25°C. for 22-24 hours, they were analyzed for chloride by the method described above. The results are presented in Table 2. From the table it appears that the chloride content of Paramecium is extremely low and, on an average, only 1.29 mg. per 100 cc. Paramecium is found, while the external solution contains 35.5 mg. Cl per 100 cc. But this figure, as it is, can not be taken to show the true chloride content, since the results, presented in the lower part of the table, indicate that a minute quantity of chloride in the presence of organic substances can only partly be detected by the method employed,[12] although CONWAY himself shows

12) For example, when the Cl content of the solution in the intercellular space is calculated (from volume × concentration) to be, say, 30 γ, this chloride, plus the chloride within the cell, is found by this method to be only 12 γ, indicating that neglecting the intracellular chloride, about 18 γ of chloride is masked in the presence of organic substances, so far as the present method employed is concerned.

that a measured amount of inorganic chloride added to and ground with tissues is fully recoverable. According to my experience, the recovery is not complete when the amount of chloride to be analyzed is less than 50 γ, and the error becomes more marked if a longer period is allowed for the process of cytolysis and protein precipitation. Therefore an accurate determination of chloride existing as a trace in organic substances (less than ca. 50 γ Cl per 1 g. of organic substances) is impossible by the present method.

TABLE 2.

Chloride content of Paramecium immersed for one day in the experimental solution.

Vol. of Paramecium analyzed	Chloride in Intercellular space calculated *	Total chloride found**	Chloride in 100 cc. Paramecium	Treatment of the cell
cc.	γ	γ	mg.	
0.41	0.0	7.2	1.75	not cytolysed
0.38	0.1	3.8	0.97	"
0.34	0.2	5.0	1.41	cytolysed
0.44	0.0	7.1	1.61	"
0.48	0.3	4.0	0.77	"
0.51	0.1	6.6	1.27	"
			Mean 1.29	
0.26	33.8	19.2		not cytolysed
0.37	24.5	18.8		"
0.40	26.6	15.3		"
0.36	30.0	12.2		cytolysed
0.38	26.5	11.2		"
0.41	22.1	12.8		"

* The Cl content of the solution in the intercellular space is calculated from volume×concentration. The concentration is known from the analysis of the supernatant fluid from final washing while the volume is obtained by the difference between the total cell volume and the volume of the Paramecium preparation subjected to analysis.

** Total chloride found means the chloride content of the preparation, namely the sum of the chloride content of the intercellular space and that within the cell.

According to Table 2, the actual situation was that, in the extreme case, only 12 γ Cl is detectable in Paramecium sample which must contain 30 γ Cl even in the intercellular space. On the other hand, when the intercellular space contains practically no chloride, the

maximum chloride content of Paramecium found in six analyses, is 7.2 γ per 0.41 cc. of the cells. Therefore the true content should not be more than 30 γ per 0.41 cc. (or 73 γ per 1 cc.) of Paramecium. This upper limit of the chloride content was confirmed beyond doubt by the result of analyses made by the open CARIUS method. In analyses of about 1 cc. of Paramecium, the white precipitates of AgCl were scarcely detectable and most of the $AgNO_3$ added was recovered by titration with NH_4CNS. When chloride of more than 123 γ was added to the Paramecium substances, the total chloride in the sample was found to be no more than the chloride added. From these results it is apparent that the chloride content of Paramecium is practically nil. Exact figures, however, could not be determined, because of the obscurity of the end point of the test method and of the fact that when the amount of chloride added is less than 88 γ the recovery becomes incomplete.

After all, it may be concluded that though the chloride content of Paramecium can not be accurately determined by the present methods, it must be less than 7.3 mg., but more than 0.77 mg., per 100 cc. of Paramecium. Consequently there is no doubt that the intracellular cations are combined with some anions other than chloride even when the organism is placed in a medium rich in chloride. Furthermore it may be mentioned that the cell membrane of Paramecium is impermeable to chloride. In view of the fact that Paramecium continuously swallows the external solution through cytostome, this result is rather striking and can not be fully explained by the sole assumption of impermeability of the cell wall to chloride. If the wall of the food vacuole is permeable to chloride, or if the vacuole discharges its contents into the cytoplasm, more chloride should be found within the cell since considerable numbers of the vacuole which contains the experimental solution rich in chloride, would be swallowed into the cell during the period of the immersion. Therefore it seems necessary to assume that the wall of the food vacuole is also impermeable to chloride and that the vacuole, though much reduced in size, does not collapse untile it is cast out from the anal

spot. According to this assumption, chloride in Paramecium is confined within the food vacuoles as chloride in muscle is found only within the intercellular space.

In the following lines some remarks on the above assumption will be given. If it were allowed to take the mean value shown in Table 2 as the chloride concentration of Paramecium, and if the vacuole immediately before its detachment from the end of the cytostome had the same chloride concentration as in the experimental solution, the total volume of the vacuoles present in one Paramecium would be calculated in the same manner as FENN and his co-workers (1934 b) calculate the volume of the chloride space in muscle. According to this calculation, it occupies 3.63% of the cell volume. However, since the food vacuole diminishes its size more or less rapidly on being detached from the end of the cytostome, the above value does not indicate the actual conditions in the cell. Hence the number of the vacuoles in one cell was calculated from the above value and the relation between the volume of Paramecium and that of the vacuole immediately before its detachment. The relation was not determined directly by observation. But according to the data presented by KAMADA (1935) and IIDA (1940 a), the volume of Paramecium kept in a M/50 balanced salt solution is $3.30 \times 10^5 \mu^3$–$2.38 \times 10^5 \mu^3$ and that of the vacuole of the cell kept in M/40 NaCl solution is $8.08 \times 10^2 \mu^3$ at the moment of its detachment. Calculations from these data show that the number of the vacuoles contained in one cell is 11–15. This number may be somewhat smaller than what might usually be observed. But if the true chloride concentration is in fact twice as great as the observed value,[13] the number of vacuoles

13. This is based on the following consideration. In Table 2, the "Total chloride" designates the chloride content of the mass of the true Paramecium plus the chloride content of the intercellular space. Therefore, the "Total Chloride" can not be less than the "Chloride in Intercellular Space". However, the data given in the lower part of Table 2 indicate that the "Chloride in Intercellular Space" is, on an average, nearly twice as large as the "Total Chloride", suggesting that, if the chloride content of Paramecium is zero, half of the chloride present is masked, when CONWAY's method is used for the determination of a small quantity of chloride mixed with organic substances.

calculated would not be very far from the expected one. Thus it may be said that the chloride found in Paramecium can be accounted for only by the chloride confined in the vacuole.

Ionic Exchange Problems

From the results of the foregoing experiments, it seems to be most probable that the cell membrane of Paramecium is permeable to cations but not to anions, and that cations on one side of the membrane can pass through the membrane in exchange with cations on the other side of it. In the present section, the net amount of cations to be gained or lost under various experimental conditions were studied with a view to obtain some quantitative data on the ionic exchange in Paramecium.

Paramecia collected from the hay culture were suspended in the " adaptation medium "[14] for one day at 25°C. These so-called " adapted Paramecia " were divided into several batches; one of them was immediately analyzed for its contents of potassium and sodium, the rest were suspended in eight different solutions shown in the second column of Table 4, after being washed thoroughly with the solution to be used. They were kept in the solution for one day more at 25°C. and then analyzed in respect of the elements to be investigated.

TABLE 3.

Sodium and potassium content of the " adapted Paramecium " (milli-equivalents per 10 g. Paramecium in dry weight

Composition of " adaptation medium "	Experimental number	Na and K content of Paramecium		
		Na	K	Na+K
$NaCl$ 0.005 M KCl 0.005 M $CaCl_2$ 0.0007 M $NaHCO_3$ 0.00024 M	1	0.81	1.20	2.01
	2	0.77	1.17	1.94
	3	0.83	1.30	2.13
	4	0.76	1.16	1.92
	5	0.72	1.25	1.97
	6	0.79	1.37	2.16
	Mean	0.78	1.24	2.02

14) $NaCl$: 0.005M, KCl: 0.005M, $CaCl_2$: 0.0007M and $NaHCO_3$: 0.00024M.

TABLE 4.

Changes in the sodium and potassium contents of the " adapted Paramecium " after being suspended in the experimental solution (milli-equivalents per 10 g. Paramecium in dry weight)

Experimental solution		Experimental number	Na and K content of Paramecium			Gain or loss (−) in Na and K content	
No. of solution	Composition		Na	K	Na+K	Na	K
I	NaCl 0.005 M KCl 0.005 M $CaCl_2$ 0.0007 M $NaHCO_3$ 0.00024 M	1	0.81	1.17	1.98	0.00	−0.03
		2	0.88	0.87	1.75	0.12	−0.30
		3	0.97	0.90	1.87	0.14	−0.40
		4	0.94	1.02	1.96	0.18	−0.14
		5	0.94	1.04	1.98	0.22	−0.21
		6	—	1.16	—	—	−0.21
		Mean	0.91	1.03	1.91	0.13	−0.22
II	NaCl 0.01 M $CaCl_2$ 0.0007 M $NaHCO_3$ 0.00024 M	1	0.81	0.56	1.37	0.00	−0.64
		2	0.82	0.76	1.58	0.05	−0.41
		3	0.72	0.64	1.36	−0.11	−0.66
		Mean	0.78	0.65	1.44	−0.02	−0.57
III	$NaHCO_3$ 0.00024 M $CaCl_2$ 0.0001 M	3	0.65	0.75	1.40	−0.18	−0.55
		6	0.77	0.67	1.44	−0.02	−0.70
		Mean	0.71	0.71	1.42	−0.10	−0.63
IV*	$NaHCO_3$ 0.00024 M	1	1.18	0.79	1.97	0.37	−0.41
		2	1.00	0.78	1.78	0.23	−0.39
		3	0.91	0.96	1.87	0.08	−0.31
		Mean	1.03	0.84	1.87	0.23	−0.38
V	KCl 0.01 M $CaCl_2$ 0.0007 M $KHCO_3$ 0.00024 M	1	0.64	1.03	1.67	−0.17	−0.17
		2	0.48	1.15	1.63	−0.29	−0.02
		5	0.50	1.03	1.53	−0.22	−0.22
		Mean	0.54	1.07	1.62	−0.23	−0.14
VI	$KHCO_3$ 0.00024 M $CaCl_2$ 0.0001 M	3	0.55	1.01	1.56	−0.28	−0.29
		5	0.52	1.04	1.56	−0.20	−0.21
		Mean	0.54	1.03	1.56	−0.24	−0.25
VII*	$KHCO_3$ 0.00024 M	1	0.66	0.95	1.61	−0.15	−0.25
		5	0.62	0.90	1.52	−0.10	−0.35
		Mean	0.64	0.93	1.57	−0.13	−0.30
VIII	$CaCl_2$ 0.0066 M $Ca(HCO_3)_2$ 0.00005 M	2	0.46	0.98	1.44	−0.31	−0.19
		5	0.44	1.15	1.59	−0.28	−0.10
		6	—	0.98	—	—	−0.39
		Mean	0.45	1.04	1.52	−0.30	−0.23

* In the second section of this paper it was remarked that the experimental solutions deprived of calcium ions cause the death of Paramecium, but in such a very dilute solution as IV or VII Paramecia usually were able to survive well without the trace of calcium apart from a few exceptional cases.

The results are summarized in Tables 3 and 4, the former showing the sodium and potassium content of the "adapted Paramecium" and the latter the changes in these contents after being suspended for one day in the experimental solution. Throughout these two table, the same experimental number indicates the batches from the same collection, while the electrolyte contents are expressed in milli-equivalents per 10 g. Paramecium in dry weight (instead of 100 g. Paramecium in wet weight). The first point to be remarked is that the "adapted Paramecia" gain sodium and lose potassium in solution I which is no other than the "adaptation medium." Therefore it may be said that one day is not sufficient for the accomplishment of electrolyte equilibrium through the cell membrane, and it is suggested that the present analyses were not always made at the true equilibrium of the organism with the surrounding medium. In the sodium solutions (solution II, III and IV), the "adapted Paramecia" lose a considerable amount of potassium, but the compensatory gain of sodium is not observed, except in the case of solution IV. It is remarkable that the sodium content within the cell does not increase but rather slightly decreases in solution II which has a higher sodium concentration than the adaptation medium. In this connection it may be worth while to mention that Paramecia can retain more solutes within in solution IV than in solution II, contrary to the expectation derived from the osmotic relation of these two solutions. However, a simple addition of a very small amount of calcium to solution IV accelerates the loss of intracellular potassium as well as of intracellular sodium (see data in solution III). This effect of calcium is not compatible with the generally accepted view that calcium causes a decrease in cellular permeability (cf. HEILBRUNN, 1937 p. 120), but recently DAVSON (1940) has also shown that calcium accelerates the rate of penetration of sodium and potassium through the cat erythrocyte.

When the "adapted Paramecia" are suspended in the potassium solutions (solution V, VI and VII), they lose not only sodium but also a considerable amount of potassium, namely the loss of intracellular sodium is not accompanied by the compensatory gain of potassium.

The loss of potassium is greater in solution VII than in solution V, while that of sodium is greater in the latter than in the former. An addition of calcium to solution VII increases the loss of intracellular sodium, but it does not affect the loss of intracellular potassium. In passing, it should be noted that the data in solution V are not in accord with the results of the foregoing experiments in which Paramecia were transferred directly from the hay culture to the potassium solution, having the same composition as solution V (see figure 1). This discrepancy will be discussed later.

In the calcium solution (solution VIII) the "adapted Paramecia" lose both potassium and sodium. In order to know whether or not they gain calcium from this calcium rich solution, they were analysed for calcium before and after the immersion (for one day at 25°C.) in this solution. The results of four experiments showed that the calcium content before the immersion (i. e. of the "adapted Paramecium") was 0.016, 0.017, 0.016 and 0.017 milli-mols per 10 g. Paramecium in dry weight, and that after the immersion was 0.019, 0.019, 0.018 and 0.019 milli-mols per 10 g. Paramecium in dry weight. The difference is strikingly small, in spite of the great difference in calcium concentration of these two external solutions. On the other hand, the calcium concentration of the "adapted Paramecium" is greater than that of the medium; namely calcium is concentrated in the cell kept for one day in the "adaption medium."[15] It is interesting to refer here to the results obtained by STEINBACH (1940) who shows that calcium can enter or leave the muscle cell of *Thyone*, but that over a certain level of the external calcium concentration, the internal calcium concentration is not increased or even decreased.

The data in Table 4 are difficult to explain, if the modification of the internal ions is assumed to be due to the simple cationic exchange through the cell membrane. The following tendency, however, can be pointed out: when the organism is transferred from the

15) In this comparison the value of calcium content so far employed was recalculated in terms of that for 100 g. of Paramecium.

"adaptation medium" to other kinds of solution, the ions newly diminished in relative quantity around the cell come out of the cell, although this exit of intracellular ions is not fully compensated by the entry of external ions. In this connection, we may assume that ions newly augmented in relative quantity around the cell really enter the cell in exchange for the out-going ions, but the organism is provided with some mechanism to discharge the excess ions[16] if the ions are concentrated within the cytoplasm above a certain level. Hence the increment of accumulated ions is always far less than the decrement of out-going ions. If the concentration once attains the critical level, the discharge may be established as a response to it, but the control of this adjusting process seems to be quantitatively inexact, so that there occurs, in some cases (or other), an over-discharge of the excess ions, with the paradoxical result that ions augmented in quantity in the medium are liable even to diminish within the cell. The critical level, the rate of cationic exchange and hence the time required to attain the critical level, may be different for different media or conditions, thus (and also owing to some other factors) complicating the numerical relation as is seen in the data of Table 4. These considerations seem to suggest one of the ways to account for the observed facts including those given in the preceding two sections. The unexpectedly low concentration of sodium at the left end of the curve in figure 1, which is so far left unexplained in view of the cationic exchange, may also find its explanation in the secondary adjustment of the accumulated ions. The discrepancy between the results shown in figure 1 and those presented in Table 4 may be accounted for by the difference in the time required to attain the critical level, since a change in permeability of the cell membrane be probably caused during immersion of cells in the innutrious saline solution for such a long period as two days, and also since the ionic composition and some other conditions within the cells may be modified in the course of "adaptation." According to the

16) One may assume here a structure similar to the tubules of vertebrate kidney or the excretory cells of the teleostean gill.

above explanation, the transfer of the organism from the " adaptation medium " to solution VIII, causes cationic exchange mainly between the external calcium ions and the internal sodium (and potassium[17]) ions. However, the penetrated calcium ions are considered to be discharged according to the principle offered above, so that at the time of analysis it was nearly at the initial level.

Summary

By means of chemical analyses of the protoplasm of Paramecium, the behavior of the principal inorganic elements (Na, K, Ca and Cl) through the cell membrane of the organism is investigated. In general these cation are retained within the cell in much higher concentration than the surrounding medium, while chloride can not be demonstrated within the protoplasm even when the organism is immersed for a consirerable time in a medium rich in chloride ions. The intracellular cations are increased or decreased in a characteristic manner, according to the composition of the external medium experimentally modified, but even with such a modification of the protoplasmic composition, the total sum of these cations remains fundamentally the same, provided the total osmolar concentration of the external medium is kept unaltered. Evidences can be pointed out that the membrane of Paramecium, probably inclusive of that of the food vacuole, is permeable to cations but not to anions. It is suggested that, if a mechanism for the secondary adjustment of the composition of protoplasm be assumed properly in the organism, some irregularities found in the data may also be accounted for on the basis of cationic exchange.

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17) The data may indicate that in the " adapted Parmecia ", in which the exchange between K_i and Na_o may be considered to have been much advanced, the internal sodium ions are in a state of higher mean mobility as compared to the internal potassium ions.

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STUDIES ON THE THORACIC MUSCULATURE OF INSECTS

Takadi MAKI

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CONTENTS

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I. INTRODUCTION

The thorax of adult insects has legs, or both legs and wings. The thorax so to speak, is a locomotion center of the body. Hence the thorax has been filled up by many muscles in complex arrangement. The complex arrangement of muscles is an interesting subject of study to anatomists, in practice it has received attention from many authors. The studies which were carried out exactly and in detail were, bowever, very few till the end of the last age. It may be said that our present knowledge on the thoracic musculature has been mainly obtained from the work of recent authors. The meritorious authors who have contributed to the advance of myology are VOSS, BERLESE, SNODGRASS, WEBER, etc. Among the works which were carried out hitherto, there are found many excellent papers dealing with one or some insects, but extensive studies, especially those of general musculature are very few.

The somatic musculature in insects has been considered as an important assistant to determine the homology of the skeletal structures of insects. In order to study the homology of muscles and to apply the results of the study of the musculature as an aid for the determination of the homology of the skeletal structures, the muscles should be as extensively observed as possible. The present paper mentions the results obtained from the comparative studies of the thoracic musculature in most of insect orders, and explains the morphology of some skeletal structures based on the comparative studies

of the musculature. In this paper, the head musculature in some apterygote insects and the musculature of the anterior abdominal segments of all the insects observed are shown in the appendix.

The main works of the thoracic musculature studies in adult insects are as follows:

The studies on apterygote insects: GRASSI (1886), VERHOEFF (1903), SNODGRASS (1927), etc.

Those on Orthoptera: GRABER (1877), LUKS (1883), MIALL and DENNY (1886), VOSS (1905), BERLESE (1909), JEZIORSKI (1918), DU PORTE (1920), CARPENTIER (1923, 1936), SNODGRASS (1929), SOLF (1931), GUNTHER and DECKERT (1933), MAKI (1935), etc.

Those on Dermaptera: MERCIER and POISSON (1923).

Those on Isoptera: FULLER (1924).

Those on Odonata: POLETAJEW (1879), LENDENFELD (1881), LUKS (1883), CALVERT (1893), BERLESE (1909), CREMER (1934), MALOUF (1935), etc.

Those on Psocoptera: BADONNEL (1934), WEBER (1936).

Those on Ephemeroptera: DÜRKEN (1907), TAKAHASHI (1932), KNOX (1935).

Those on Hemiptera: LUKS (1883), WITLACZIL (1885), LIST (1886), BERLESE (1909), WEBER (1928a, 29), MILLER (1933a), MALOUF (1933), etc.

Those on Neuroptera: WEBER (1928b), MILLER (1933b), MAKI (1936).

Those on Lepidoptera: POLETAJEW (1880), LUKS (1883), BERLESE (1909), WEBER (1924, 28b), ect.

Those on Coleoptera: STRAUS-DÜRKHEIM (1828), LUKS (1883), CAMERANO (1893), BERLESE (1909), BAUER (1910), STELLWAAG (1914), RÜSCHKAMP (1927, 28), CARPENTIER (1929), JACKSON (1933), MURRAY and TIEGS (1935), etc.

Those on Hymenoptera: LUBBOCK (1881), LUKS (1883), JANET (1897), PETRI (1899), BERLESE (1909), STELLWAAG (1910), BRUNNICH (1911), MORISON (1927), WEBER (1925, 27), BETTS (1933), etc.

Those on Diptera: GRABER (1877), LUKS (1883), PETRI (1899), BERLESE (1909), CUÉNOT and MERCIER (1923), FEUERBORN (1927), TOWNSEND (1927), MIHÁLYI (1936), etc.

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II. METHODS

The specimens used for the investigation of the skeletal structure were soaked from five to twenty minutes in a 10 per cent boiling solution of potassium hydroxide. The specimens for the study of the musculature were preserved by hardening in a solution containing 75 per cent of alcohol and 2 per cent of formaldehyde, and both were dissected in water under observation with a binocular microscope.

The skeletal structures were figured by the aid of a camera lucida. The muscular arrangements were shown by diagrams as we can see them at a glance, and the attached positions of muscles were represented by closely dotted areas, in the figures of the skeletal structures.

III. MATERIAL

The specimens observed in this work are listed as follows:

Apterygota.
- Thysanura.
  - Machilidae.
    - *Pedetontus sp.* (Fig. 1)
  - Lepismidae.
    - *Lepisma saccharina* LINNAEUS (Fig. 2)
  - Campodeidae.
    - *Lepidocampa weberi* OUDEMAN (Fig. 3)
- Collembola.
  - Poduridae.
    - *Neanura dubiosa* RITTER (Fig. 4)
  - Entomobryidae.
    - *Folsomia sp.* (Fig. 5)

Pterygota.
- Hemimetabola.
  - Orthoptera.
    - Blattidae.
      - *Periplaneta australasiae* LINNAEUS (Fig. 6)
    - Mantidae.
      - *Hierodula patellifera* SERVILLE (Fig. 7)
    - Acridiidae.
      - *Locusta migratoria manilensis* MEYEN (Fig. 8)
      - *Atractomorpha ambigua* BOLIVAR (Fig. 9)
    - Tettigonidae.
      - *Xiphidion maculatum* GUILLON (Fig. 10)
    - Gryllidae.
      - *Brachytrupes portentosus* LICHTENSTEIN (Fig. 11)
  - Dermaptera.
    - Labiduridae.
      - *Anisolabis annulipes* LUCAS (Fig. 12)
    - Labiidae.

Labia curvicauda MOTSCHULSKY (Fig. 13)

Plecoptera.

Perlidae.

Neoperla formosana OKAMOTO (Fig. 14)

Isoptera.

Metatermitidae.

Odontotermes formosanus SHIRAKI (Fig. 15)

Embioptera.

Oligotomidae.

Oligotoma saundersi WESTWOOD (Fig. 16)

Psocoptera.

Psocidae.

Psocus tokyoensis ENDERLEIN (Fig. 17)

Ephemeroptera.

Ecdyonuridae.

Ecdyonurus hyalinus ULMER (Fig. 18)

Odonata.

Libellulidae.

Crocothemis servila DRURY (Fig. 19)

Agrionidae

Psolodesmus mandarinus MCLACHLAN (Fig. 20)

Thysanoptera.

Phloeothripidae.

Machatothrips artocarpi MOULTON (Fig. 21)

Hemiptera.

Pentatomidae.

Eurostus validus DALLAS (Fig. 22)

Corixidae.

Sigara substriata UHLER (Fig. 23)

Cicadidae.

Huechys sanguinea (DE GEER) var.
philaemata FABRICIUS (Fig. 24)

Jassidae.

Cicadella ferruginea FABRICIUS (Fig. 25)

Psyllidae.

Macrohomotoma gladiatum KUWAYAMA (Fig. 26)

Holometabola.

Mecoptera.

Panorpidae.

Neopanorpa ophthalmica NAVAS (Fig. 27)

Trichoptera.

Stenopsychidae.

Stenopsyche griseipennis MACLACHLAN (Fig. 28)

Lepidoptera.

Plutellidae.

Plutella maculipennis CURTIS (Fig. 29)

Tortricidae.

Adoxophyes privatana WALKER (Fig. 30)

Papilionidae.

Papilio thaiwanus ROTHSCHILD (Fig. 81)

Geometridae.

Milionia zonea MOORE (Fig. 32)

Syntomidae.

Amata lucerna WILEM (Fig. 33)

Coleoptera.

Cicindelidae.

Cicindela kaleea BATES (Fig. 34)

Carabidae.

Chlaenius naeviger MORAWITZ (Fig. 35)

Staphylinidae.

Borolinus minutus CASTERNAU (Fig. 36)

Coccinellidae.

Epilachna vigintioctopunctata FABRICIUS (Fig. 37)

Tenebrionidae.

Ceropria induta WIEDEMANN (Fig. 38)

Chrysomelidae.

Rhaphidopalpa femoralis MOTSCHULSKY (Fig. 39)

Scarabaeidae.

Mimela testaceoviridis BLANCHARD (Fig. 40)

Hymenoptera.

Tenthredinidae.

Eutomostethus formosanus ENSLIN (Fig. 41)

Ichneumonidae.

Philopsyche sauteri CUSHMAN (Fig. 42)

Vespidae.

Vespa ducalis SMITH (Fig. 43)

Diptera.

Tipulidae.

Ctenacroscelis mikado WESTWOOD (Fig. 44)

Stratiomyidae.

Pecticus latifascia WALKER (Fig. 45)

Syrphidae.

Lathyrophthalmus obscuritarsis DE MEIJERE. (Fig. 46)

Micropezidae.

Calobata sinensis ENDERLEIN (Fig. 47)

Muscidae.

Orthellia claripennis MALL (Fig. 48)

IV. MUSCULATURE IN THE INSECT THORAX

The thoracic muscles of insects are divisible, in general, into the following kinds:

a. Dorsal longitudinal or oblique muscles, both ends being attached on the tergal regions.

b. Dorsal transverse muscles arising on the anterior portions of the tergum and attached on the ventral side of the dorsal vessel.

c. Muscles of the pulsating membranes of the dorsal vessel.

d. Ventral longitudinal or oblique muscles, both ends attached on the sternal regions.

e. Ventral transverse muscles stretched between the latero-ventral regions of the segment over the ventral nerve cord, or arising on the

latero-ventral regions of the segment, passing between the connectives of the ventral nerve cord from the upper side of the connectives and attached on the median portion of the sternum.

f. Tergo-sternal muscles stretched between the tergal and the sternal regions.

g. Tergo-pleural muscles stretched between the tergal and the sternal regions.

h. Sterno-pleural muscles stretched between the sternal and the pleural regions.

i. Pleural muscles stretched between the pleural sclerites, except the muscles belonging to the next kind.

j. Muscles stretched between the leg bases and the thorax. All these in wingless segments are leg muscles; most of these in wing-bearing segments are leg muscles, and some have been often transformed into wing muscles.

k. Intrinsic leg muscles arising on the leg segments.

l. Spiracular muscles arising on or near the lateral intersegmental regions and attached on the spiracles.

m. Thoracic intestinal muscles arising on the thorax and attached on the intestine.

n. Thoracic genital muscles arising on the thorax and attached on the gonads.

The muscles of the palsating membranes, the intrinsic leg muscles, the intestinal and the genital muscles are not mentioned here.

i. APTERYGOTA

1. THYSANURA

A. Machilidae

Pedetontus sp. (Fig. 1)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has two dorsal muscles on each side, a broad

longitudinal bundle (Fig. 1, **1**) attached anteriorly on the posterior margin of the head and posteriorly on the anterior end of the mesotergum near the dorsal median line, and an oblique bundle (Fig. 1, **2**) arising on the posterior margin of the head near the dorsal median line and inserted into the anterior end of the mesotergum outside the preceding muscle.

2) **Ventral Muscles**

Three ventral muscles are found on each side: the first (Fig. 1, **3**) is a longitudinal muscle attached anteriorly to the posterior tentorial arm, and posteriorly to the anterior end of the mesosternum by a membranous tendon; the second (Fig. 1, **4**) is a longitudinal muscle attached on the outside of the first; the third (Fig. 1, **5**) is a very small tendinous muscle arising on the postero-lateral portion of the prosternal plate and inserted into the anterior end of the mesosternum by a membranous tendon.

3) **Tergo-Sternal Muscles**

On each side are found four tergo-sternal muscles: the first (Fig. 1, **6**) is an oblique slender muscle arising on the posterior lateral margin of the head and inserted into the anterior end of the mesosternum by a membranous tendon, the second (Fig. 1, **7**) is a very slender vertical muscle originating on the anterior end of the dorso-lateral region of the protergum and attached on the outside of the base of the posterior tentorial arm, the third (Pig. 1, **8**) is an oblique long muscle attached posteriorly on the anterior portion of the dorso-lateral region of the metatergum and anteriorly on the outside of the base of the posterior tentorial arm, the fourth (Fig. 1, **9**) is a slender muscle arising on the middle portion of the lateral region of the protergum and inserted into the anterior end of the mesosternum by a membranous tendom.

4) **Tergo-Pleural Muscles**

Two tergo-pleural muscles are found on each side, one (Fig. 1, **10**) oblique, slender, arising on the anterior portion of the dorso-lateral region of the protergum and inserted into the posterior portion of the propleuron, the other (Fig. 1, **11**) vertical, arising on the posterior por-

tion of the dorso-lateral region of the protergum and inserted into the posterior small triangular sclerite of the propleuron.

5) **Coxal Muscles**

The coxal muscles of each side are in bundles of nine: A thick tergal promotor (Fig. 1, **12**) arising on the middle portion of the dorso-lateral region of the tergum and inserted into the anterior basal margin of the coxa; two sternal promotors, one (Fig. 1, **15**) arising on the ventral median portion of the cervical region and attached on the anterior basal wall of the coxa, the other (Fig, 1, **16**) originated on the lateral portion of the anterior end of the mesosternum and attached on the anterior basal rim of the coxa; two tergal remotors, an oblique very thick bundle (Fig. 1, **13**) arising on the anterior portion of the dorso-lateral region of the tergum beneath the dorsal end of the first tergo-pleural muscle (Fig. 1, **10**) and inserted into the internal process of the postero-lateral basal margin of the coxa, and a vertical strong bundle (Fig. 1, **14**) arising on the posterior portion of the dorso-lateral region of the tergum inside the dorsal end of the second tergo-pleural muscle (Fig. 1, **11**) and inserted into the apex of the internal process on the postero-lateral basal margin of the coxa; a fan-shaped transverse sternal remotor (Fig. 1, **17**) arising on the spina at the anterior end of the mesosternum by a spreading base and inserted into the basal wall of the postero-lateral portion of the coxa; three tergal abductors, the first (Fig. 1, **18**) is an oblique slender muscle arising on the lateral portion of the posterior margin of the head below the dorsal end of the first tergo-sternal muscle (Fig. 1, **6**) and inserted into the antero-lateral portion of the basal margin of the coxa, the second (Fig. 1, **19**) is a very thick muscle arising on the anterior dorso-lateral region of the tergum behind the dorsal end of the first tergo-pleural muscle (Fig. 1, **10**) and inserted into the antero-lateral portion of the basal margin of the coxa, the third (Fig. 1, **20**) is a vertical muscle attached dorsally on the posterior dorso-lateral region of the tergum outside the dorsal end of the second tergo-pleural muscle (Fig. 1, **11**) and ventrally on the lateral basal margin of the coxa:

6) Trochanteral Muscles Arising on the Thorax

Two trochanteral muscles are found on each side, a very slender tergal depressor (Fig. 1, 21) arising on the middle of the lateral region of the protergum behind the dorsal end of the fourth tergo-sternal muscle (Fig. 1, 9) and inserted into the ventral base of the trochanter, and a very thick sternal depressor (Fig. 1, 22) arising on the lateral portion of the anterior end of the mesosternum and inserted into the ventral base of the trochanter.

b. Mesothoracic Musculature

1) Dorsal Muscles

The dorsal muscles of each side are in two bundles, median and lateral. The median dorsal muscle (Fig. 1, 23) is broad, slightly oblique, arising on the anterior median portion of the tergum and attached on the anterior portion of the metatergum more or less far from the dorsal median line. The lateral dorsal muscle (Fig. 1, 24) is oblique, arises on the middle of the dorso-lateral region of the tergum and attaches on the antero-lateral portion of the metatergum.

2) Ventral Muscles

There are three kinds of ventral muscles: The first is of one-paired lateral longitudinal muscles (Fig. 1, 25) stretched between the anterior ends of the meso- and metasternum; the second is of an unpaired very slender median muscle (Fig. 1, 26) stretched between the spinae of the anterior ends of the meso- and metasternum; the third is of a one-paired very small oblique muscle (Fig. 1, 27) arising on the posterior portion of the mesosternal plate near the median line and inserted into both sides of the anterior end of the metasternum.

3) Ventral Transverse Muscles

On the anterior end of the segment there are a pair of ventral transverse muscles, each arises on the median apophysis between the connectives of the ventral nerve cord and is attached on the lateral portion of the sternum over the connective. (Fig. 1, 28)

4) Tergo-Sternal Muscles

Seven tergo-sternal muscles are on each side: The first (Fig. 1, **29**) is vertical, arising on the anterior portion of the dorso-lateral region of the tergum; the second (Fig. 1, **30**) is very thick, arising on the dorso-lateral region of the tergum behind the first; the third (Fig. 1, **31**) is slender, originating on the anterior end of the dorso-lateral region of the metatergum; the fourth (Fig. 1, **32**) arises on the lateral portion of the anterior end of the metatergum; all the four are attached on the lateral portion of the anterior end of the sternum by a tendinous membrane; the fifth (Fig. 1, **33**) is small, it takes its origin on the anterior lateral portion of the tergum and is inserted into the lateral end of the presternum; the sixth (Fig. 1, **34**) arises on the portion somewhat posterior to the middle of the lateral region of the tergum and is attached on the middle of the lateral region of the main sternal plate; the seventh (Fig. 1, **35**) originates on the posterior portion of the dorso-lateral region of the tergum and is attached on the lateral portion of the anterior end of the metasternum by a membranous tendon.

5) Tergo-Pleural Muscles

The tergo-pleural muscles are two-paired. The first pair (Fig. 1, **36**) are very small muscles connecting the middle portions of both sides of the tergum with the dorsal bases of the pleural arms. The second pair (Fig. 1, **37**) arise on the lateral portions of the tergum behind the first and attach on the pleural arms.

6) Sterno-Pleural Muscles

The sterno-pleural muscles are two-paired, one pair (Fig. 1, **38**) arise on the middle portions of both sides of the main sternal plate, the other (Fig. 1, **39**) arise on the postero-lateral corners of the main sternal plate, both pairs attach on the pleural arms.

7) Coxal Muscles

On each side there are six coxal muscles as follows: a very thick tergal promotor (Fig. 1, **40**) arising on the middle of the dorso-lateral region of the tergum and inserted into the anterior basal rim of the coxa; a slender sternal promotor (Fig. 1, **43**) connecting the anterior

2) Ventral Muscles

Four ventral muscles are found on each side: A thick internal longitudinal muscle (Fig. 2, **8**) arising on the posterior tentorial arm and attached on the intersegmental membrane anterior to the antero-lateral corner of the mesósternum, a slender external longitudinal muscle (Fig. 2, **9**) arising on the postero-lateral portion of the sub-mentum and inserted into the posterior intersegmental membrane as the preceding muscle, a very small muscle (Fig. 2. **9a**) arising on the membrane near the inside of the coxal base and attached on the posterior intersegmental membrane as the two preceding muscles, a short oblique muscle (Fig. 2, **10**) originating on the lateral margin of the posterior sternite and attached on the antero-lateral corner of the mesosternum.

3) Ventral Transverse Muscles

A pair of very slender ventral transverse muscles (Fig. 2, **11**) arise on the median apophysis between the pro- and mesosternum and are attached on the posterior intersegmental membrane near the antero-lateral corners of the mesosternum.

4) Tergo-Sternal Muscles

Six tergo-sternal muscles are found on each side: The first (Fig. 2, **12**) is attached dorsally on the lateral portion of the posterior end of the head and ventrally on the lateral portion of the presternum; the second (Fig. 2, **13**) arising on the antero-lateral portion of the tergum and attached on the lateral portion of the presternum; the third (Fig. 2, **14**) originating on the lateral portion of the anterior end of the mesotergum and attached on the posterior tentorial arm; the fourth Fig. 2, **15**) arising on the antero-lateral portion of the tergum, passing the outside of the first and second tergo-sternal muscles and attached on the posterior tentorial arm; the fifth (Fig. 2, **16**) originating in the middle of the dorso-lateral region of the tergum and inserted into the ventral membrane near the inside of the coxal base; the sixth (Fig. 2, **17**) taking its origin on the anterior end of the dorso-lateral region of the mesotergum and its insertion into the intersegmental membrane before the antero-lateral córner of the mesosternum.

5) Tergo-Pleural Muscles

On each side there are three tergo-pleural muscles: A slender anterior bundle (Fig. 2, **18**) arising on the lateral portion of the posterior end of the head and attached on the dorsal portion of the pleuron, a vertical bundle (Fig. 2, **19**) originated on the anterior portion of the dorso-lateral region of the tergum and attached on the anterior portion of the pleuron, a small bundle (Fig. 2, **20**) arising on the middle of the dorso-lateral region of the tergum and inserted into the dorso-posterior portion of the pleuron.

6) Sterno-Pleural Muscles

A pair of very long intersegmental sterno-pleural muscles (Fig. 2, **21**) are attached posteriorly on the median apophysis between the meso- and metasternum and anteriorly on the dorsal portions of the pleura.

7) Coxal Muscles

On each side are found eight coxal muscles as follows: A thick tergal promotor (Fig. 2, **22**) taking its rise on the anterior portion of the dorso-lateral region of the tergum and its insertion into the trochantin at the coxo-trochantinal joint; a long sternal promotor (Fig. 2, **26**) arising on the base of the posterior tentorial arm and attached on the anterior basal wall of the coxa in the opposite side; three tergal remotors, a very thick bundle (Fig. 2, **23**) arising on the middle of the dorso-lateral region of the tergum and attached on the posterior basal wall of the coxa, an outer bundle (Fig. 2, **24**) taking its origin and insertion on the outside of the first bundle, a posterior bundle (Fig. 2, **25**) arising on the tergum behind the first bundle and attached on the posterior basal rim of the coxa; two sternal remotors, the first (Fig. 2, **27**) arising on the median portion of the posterior sternite by a wide base and inserted into the internal process of the posterior basal wall of the coxa, the second (Fig. 2, **28**) originating on the spina at the posterior end of the sternum and attached on the posterior basal wall of the coxa; a pleural abductor (Fig. 2, **29**) arising on the dorsal portion of the pleuron and inserted into the lateral basal wall of the coxa.

8) Trochanteral Muscles Arising on the Thorax

Three depressors of the trochanter are observed on each side: A thick tergal depressor (Fig. 2, **30**) arising on the portion more or less anterior to the middle of the dorso-lateral region of the tergum, a pleural depressor (Fig. 2, **31**) originated on the dorsal portion of the pleuron, a very slender sternal depressor (Fig. 2, **32**) arising on the ventral membrane near the inside of the coxal base; all these are attached ventrally on the ventral base of the trochanter.

b. Mesothoracic Musculature

1) Dorsal Muscles

Five dorsal muscles are found on each side. The first (Fig. 2, **33**) is a median longitudinal muscle arising in the middle of the median region of the tergum attached on the anterior end of the meso-tergum near the median line. The second (Fig. 2, **34**) is a lateral longitudinal muscle situated on the outside of the first, stretched between the anterior ends of the meso- and metatergum. The third (Fig. 2, **35**) is an oblique slender muscle arising in the middle of the median region of the tergum and attached on the lateral portion of the anterior end of the metatergum. The fourth (Fig. 2, **36**) is very thick, arising on the antero-median portion of the tergum and attached on the postero-lateral portion of the tergum. The fifth (Fig. 2, **37**) is similar to the fourth, but situated on the outside of the fourth.

2) Dorsal Transverse Muscles

A pair of very slender dorsal transverse muscles (Fig. 2, **38**) arise on the anterior end of the dorso-lateral region of the tergum and are attached on the dorsal vessel.

3) Ventral Muscles

Three ventral muscles are found on each side: a thick internal longitudinal muscle (Fig. 2, **39**) is stretched between the interseg-mental membranes before the antero-lateral corners of the meso- and metasternum; a slender external ventral muscle (Fig. 2, **40**) arising on the antero-lateral corner of the sternum and attached on the in-

tersegmental membrane as the posterior end of the internal muscle; an oblique ventral muscle (Fig. 2, **41**) arising on the antero-median portion of the sternum and attached on the antero-lateral corner of the metasternum.

4) **Ventral Transverse Muscles**

Two pairs of very slender ventral transverse muscles are found on the ventral side of the segment. The first pair (Fig. 2, **42**) are anterior muscles arising on the antero-lateral corners of the sternum and attached on the median apophysis at the anterior end of the sternum, the second (Fig. 2, **43**) are posterior muscles originating in the intersegmental membrane near the antero-lateral corners of the metasternum, and inserted into the median apophysis at the anterior side of the metasternum.

5) **Tergo-Sternal Muscles**

Five tergo-sternal muscles are observed on each side. The first (Fig. 2, **44**) is a slender muscle connecting the anterior end of the dorso-lateral region of the tergum with the antero-lateral corner of the sternum. The second (Fig. 2, **45**) is a very slender muscle arising in the middle of the dorso-lateral region of the tergum and inserted into the membrane near the inside of the coxal base. The third (Fig, 2. **46**) is a muscle originating on the anterior end of the dorso-lateral region of the metatergum, and inserted into the membrane near the inside of the coxal base. The fourth (Fig. 2, **47**) arises in the antero-lateral corner of the metatergum and is attached on the antero-median portion of the sternum. The fifth (Fig. 2, **48**) is a slender muscle arising in the antero-lateral corner of the sternum and attached on the subspriraculare.

6) **Tergo-Pleural Muscles**

The tergo-pleural muscles are three-paired. The first pair (Fig. 2, **49**) arise on the anterior portions of the dorso-lateral regions of the tergum and are attached on the anterior portions of the pleura, the second (Fig. 2, **50**) are very small, take the origins on the portions somewhat anterior to the middle portions of the lateral regions of the tergum, the third (Fig. 2, **51**) are small, arising on the position more

or less posterior to the middle portions of the lateral regions of the tergum, the last two pairs are attached on the dorsal portions of the pleura.

7) Sterno-Pleural Muscles

The sterno-pleural muscles (Fig. 2, **52**) are very similar to those in the prothorax, arising on the spina at the anterior side of the first abdominal sternum and attached on the dorsal portions of the meso-pleura.

8) Coxal Muscles

Nine coxal muscles are found on each side: Two tergal promotors, an anterior muscle (Fig. 2, **53**) arising on the anterior end of the dorso-lateral region of the tergum, a posterior muscle (Fig. 2, **54**) originated on the portion more or less anterior to the middle of the dorso-lateral region of the tergum, both are attached on the trochantin at the coxo-trochantinal joint; a sternal promotor (Fig. 2, **58**) arising on the antero-median portion of the sternum and attached on the anterior wall of the coxa; three tergal remotors (Fig. 2, **55, 56, 57**) very similar to those in the prothorax (Fig. 2, **23, 24, 25**) respectively; two sternnl remotors, one (Fig. 2, **59**) arising on the median portion of the main sternite and attached on the posterior basal wall of the coxa, the other (Fig. 2, **60**) similar to the second sternal remotor in the prothorax (Fig. 2, **28**); a pleural abductor (Fig. 2, **61**) similar to that in the prothorax (Fig. 2, **29**)

9) Trochanteral Muscles Arising on the Thorax

The trochanteral muscles are five-paired: The first pair (Fig. 2, **62**) are tergal depressors similar to those in the prothorax, the second to the fourth pairs (Fig. 2, **63, 64, 65**) are pleural depressors arising on the dorsal portions of the pleura and attached on the ventral bases of the trochanters, the fifth pair (Fig. 2, **66**) are sternal depressors very similar to those in the prothorax (Fig. 2, **32**).

10) Muscles of the Spiracle

The first thoracic spiracle has an occlusor arisihg on the ventral end of the subspiraculare and inserted into the ventral side of the spiracle (Fig. 2, **67**).

c. Metathoracic Musculature

The matathoracic dorsal muscles (Fig. 2, **68, 69, 70, 71, 72**) correspond to the mesothoracics (Fig. 2, **33, 34, 35, 36, 37**), the metathoracic dorsal transverse muscle (Fig. 2, **73**) to the mesothoracic (Fig. 2, **38**), the metathoracic ventral muscles (Fig. 2, **74, 75, 76**) to the mesothoracics (Fig. 2, **39, 40, 41**), the metathoracic ventral transverse muscles (Fig. 2, **77, 78**), to the mesothoracics (Fig. 2, **42, 43**), the metathoracic tergo-sternal muscles (Fig. 2, **79, 80, 81, 82, 82a**) to the mesothoracics (Fig. 2, **44, 45, 46, 47, 48**), the metathoracic tergo-pleural muscles (Fig. 2, **83, 84, 85**) to the mesothoracics (Fig. 2, **49, 50, 51**), the metathoracic sterno-pleural muscle (Fig. 2, **86**) to the mesothoracic (Fig. 2, **52**), the metathoracic coxal muscle (Fig. 2, **87, 88, 89, 90, 91, 92, 93, 94, 95**) to the mesothoracics (Fig. 2, **53, 54. 55, 56, 57, 58, 59, 60, 61**), the metathoracic trochanteral muscles (Fig. 2, **96, 97, 98. 99, 100**) to the mesothoracics (Fig. 2, **62, 63, 64, 65, 66**), the first thoracic spiracular muscle (Fig. 2, **101**) to the second thoracic (Fig. 2, **67**), respectively. The metathoracic muscles resemble the mesothoracics, but the sterno-pleural muscle (Fig. 2, **86**) arises posteriorly on the middle of the lateral region of the first abdominal sternum.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 2, and Table I.

C. Campodeidae

Lepidocampa weberi OUDEMAN (Fig. 3)

a. Head Musculature

1) Dilators of the Pharynx

Four kinds of dilators are found on the pharynx, the first (Fig. 3, **1**) is an unpaired median dorsal dilator arising on the median portion of the frons between the antennae, and inserted into the dorsal

portion of the pharynx, the second (Fig. 3, **2**) is an unpaired median dorsal dilator arising on the frons above the dorsal end of the first and attached on the pharynx behind the first; the third (Fig. 3, **3**) is one-paired lateral dilators arising on the frons beneath the antennae, diverging and attached on both sides of the pharynx; the fourth (Fig. 3, **4**) is one-paired slender ventral dilators taking the origins and insertions on the antero-median portion of the tendinous tentorial plate of the head and into the ventral side of the pharynx respectively.

2) **Labral Muscle**

An unpaired median muscle (Fig. 3, **5**) arises on the lower portion of the frons and attaches on the epipharynx near the apex of the labrum.

3) **Clypeal Muscles**

A pair of clypeal muscles (Fig. 3, **6**) arise on the tentorial plate of the head and are attached on both sides of the epistomal ridge.

4) **Antennal Muscles**

Four antennal muscles are observed on each side: The first (Fig. 3, **7**) is a levator of the antenna, attached on the dorsal basal rim of the scape; the second (Fig, 3, **8**) is a depressor of the antenna, attached on the ventral basal rim of the scape; the third (Fig. 3, **9**) is an extensor of the flagellum, attached on the lateral base of the pedicel; these three muscles take their rise on the lateral portion of the tentorial plate; the fourth (Fig. 3, **10**) is a very short flexor of the flagellum, arising on the inner basal portion of the scape and attached on the inner basal rim of the pedicel.

5) **Mandibular Muscles**

On the mandible are attached five muscles: The first (Fig. 3, **11**) is very thick, arising on the lateral portion of the head immediately behind the postfrontal ridge and attached on the inner basal rim of the mandible; the second (Fig. 3, **12**) is slender, arising on the posterior transverse ridge of the head and attached on the dorsal basal rim of the mandible; the third (Fig. 3, **13**) is very thick, originating on the median portion of the head along the coronal ridge and attached on the lateral basal rim of the mandible; the fourth (Fig. 3,

14) is also very thick, arising on the antero-lateral portion of the tendinous tentorial plate and attached on the lateral wall of the mandible; the fifth (Fig. 3, 15) is small, taking its origin on the lateral portion of the tendinous tentorial plate and is inserted into the ventral basal rim of the mandible.

6) **Maxillary Muscles**

Three maxillary muscles arising on the head are observed on each side; the first (Fig. 3, 16) arises on the posterior transverse ridge of the head and is attached on the proximal portion of the cardo; the second (Fig. 3, 17) is very long, arising on the posterior transverse ridge of the head and is attached on the inner base of the lacinia; the third (Fig. 3, 18) is a muscle arising on the lateral portion of the tendinous tentorial plate. Its attached position on the maxilla was not observed in detail.

7) **Labial Muscles**

Five labial muscles are found on each side: The first (Fig. 3, 19) arises on the tendinous tentorial plate and is attached on the median portion of the ventral intersegmental membrane at the posterior end of the labial segment between the connectives of the ventral nerve cord; the second (Fig. 3, 20) arises on the tendinous tentorial plate and is attached on the internal process of the lateral portion of the submentum; the third (Fig. 3, 21) is very slender, connecting the tentorial plate with the basal margin of the mentum (?); the fourth and fifth (Fig. 3, 22, 23) arise on the tentorial plate and are attached on the inner portion of the anterior appendage.

8) **Tergo-Sternal Muscles**

A pair of tergo-sternal muscles (Fig. 3, 24) arise on the middle portions of the latero-dorsal regions of the head and are attached on both sides of the tentorial plate.

b. Prothoracic Musculature

1) **Dorsal Muscles**

The dorsal muscles are three-paired: The first pair (Fig. 3, 25)

are median internal longitudinal muscles, each is attached anteriorly on the dorso-lateral portion of the head capsule and posteriorly on the posterior portion of the mesotergum near the median line; the second pair (Fig. 3, **26**) are median external longitudinal muscles, each is stretched between the anterior side of the protergal plate and the posterior portion of the mesotergum near the median line; the third pair (Fig. 3, **27**) are anterior muscles, each arises on the dorso-lateral portion of the head and is inserted into the anterior side of the protergal plate near the median line.

2) **Ventral Muscles**

Two ventral muscles are found on each side: A median longitudinal muscle (Fig. 3, **28**) stretching between both ends of the sternum at the ventral median line, an oblique muscle (Fig. 3, **29**) arising on the anterior end of the median of the sternum and inserted into the anterior end of the lateral of the mesosternum.

3) **Tergo-Sternal Muscles**

Five tergo-sternal muscles are observed on each side: The first (Fig. 3, **30**) arises on the anterior side of the protergal plate near the dorsal median line and is inserted into the median portion of the anterior end of the sternum; the second (Fig. 3, **31**) is very long, arises on the postero-lateral portion of the meso-tergum and attaches on the median portion of the anterior end of the sternum; the third (Fig. 3, **32**) is slender, taking its rise on the middle of the dorso-lateral region of the tergal plate and is inserted into the lateral wing of the main sternite; the fourth (Fig. 3, **33**) is slender, arising on the middle of the dorso-lateral region of the tergal plate and is attached on the postero-median portion of the sternum; the fifth (Fig. 3, **34**) originates on the anterior portion of the dorso-lateral region of the mesotergum and is attached on the postero-median portion of the sternum.

4) **Coxal Muscles**

Eight muscles are attached on the base of the coxa: A tergal promotor (Fig. 3, **35**) arising on the middle of the dorso-lateral region of the tergal plate and attached on the trochantin at the coxo-trochantinal joint; a sternal promotor (Fig. 3, **36**) arising on the median por-

tion of the anterior end of the sternum and inserted into the antero-lateral basal wall of the coxa; four tergal remotors, the first (Fig. 3, **37**) arising on the dorso-lateral region of the tergum behind the tergal promotor by a wide base, the second (Fig. 3, **38**) originating on the middle of the dorso-lateral region of the mesotergum, and both are attached on the posterior basal rim of the coxa, the third (Fig. 3, **39**) arising on the middle of the dorso-lateral region of the tergum and attached on the postero-lateral basal wall of the coxa, the fourth (Fig. 3, **40**) originating on the anterior of the dorso-lateral region of the mesotergum and inserted into the postero-lateral basal wall of the coxa; a sternal remotor (Fig. 3, **41**) arising on the postero-median portion of the sternum and inserted into the postero-lateral basal wall of the coxa; a tergal abductor (Fig. 3. **42**) arising on the dorso-lateral portion of the posterior end of the head and attached on the antero-lateral basal wall of the coxa.

5) Trochanteral Muscles Arising on the Thorax

A pair of sternal depressors of the trochanters (Fig. 3, **43**) arising on the postero-median portion of the sternum and attached on the ventral bases of the trochanters.

c. Mesothoracic Musculature

1) Dorsal Muscles

The dorsal muscles are two-paired: The first pair (Fig. 3, **44**) are thick, arising on the antero-median portions of the tergum behind the transverse tergal ridge and attached on the antero-lateral portions of the metatergum before the anterior transverse ridge; the second pair (Fig. 3, **45**) are oblique, arising on the middle of the median region of the tergum, and attached on the antero-lateral portions of the metatergum as the first.

2) Ventral Muscles

The ventral muscles are two-paired: The first pair (Fig. 3, **46**) are longitudinal, stretched between the antero-lateral corners of the

meso- and metasternum; the second pair (Fig. 3, **47**) are oblique, arising on the antero-lateral corners of the sternum and attached on the posterior end of the median region of the sternum.

3) **Tergo-Sternal Muscles**

On each side are found five tergo-sternal muscles: The first (Fig. 3, **48**) arises on the lateral portion of the anterior transverse ridge of the tergum and is attached on the lateral end of the presternum; the second (Fig. 3, **49**) is very long, arising on the postero-lateral portion of the metatergum and is attached on the posterior end of the median region of the prosternum; the third (Fig. 3, **50**) is slender, taking its origin on the posterior portion of the dorso-lateral region of the tergum and is inserted into the lateral wing of the main sternal plate; the fourth (Fig. 3, **51**) is a slender muscle arising on the posterior portion of the dorso-lateral region of the tergum and attached on the postero-median portion of the sternum; the fifth (Fig. 3, **52**) is attached dorsally on the anterior portion of the dorso-lateral region of the metatergum and ventrally on the postero-median portion of the mesosternum.

4) **Coxal Muscles**

Eight coxal muscles are observed on each side: A tergal promotor (Fig. 3, **53**) arising on the posterior portion of the dorso-lateral region of the tergum and inserted into the trochantin as that of the prothorax; a sternal promotor (Fig. 3, **54**) similar to that of the prothorax (Fig. 3, **36**); four tergal remotors, the first and second (Fig. 3, **55, 56**) arise on the posterior of the dorso-lateral region of the tergum and are attached on the posterior basal rim of the coxa, the third (Fig. 3, **57**) arises on the anterior of the dorso-lateral region of the tergum, the fourth (Fig. 3, **58**) arises on the middle of the dorso-lateral region of the tergum, and the last two muscles are attached on the postero-lateral basal wall of the coxa; a sternal remotor (Fig. 3, **59**) similar to that in the prothorax (Fig. 3, **41**); a tergal abductor (Fig. 3, **60**) arising on the posterior of the dorso-lateral region of the tergum and inserted into the antero-lateral basal rim of the coxa.

5) Trochanteral Muscles Arising on the Thorax

A pair of sternal depressors of the trochanters (Fig. 3, **61**) similar to those in the prothorax are found on the mesothorax.

d. Metathoracic Musculature

1) Dorsal Muscles

The dorsal muscles are three-paired, the first and second pairs (Fig. 3, **62 63**) are similar to the first dorsal muscles in the mesothorax, the third pair (Fig. 3, **64**) are similar to the second dorsal muscles of the mesothorax.

2) Dorsal Transverse Muscles

A pair of dorsal transverse muscles arise on the antero-lateral portions of the tergum and are attached on the dorsal vessel. (Fig. 3, **65**).

3) Ventral Muscles

The ventral muscles (Fig. 3, **66, 67**) are very similar to those in the mesothorax, but the posterior end of the first bundle of the metathorax (Fig. 3, **6€**) is more inward than that in the mesothorax and is attached on the anterior end of the following sternum.

4) Tergo-Sternal Muscles

The tergo-sternal muscles (Fig. 3, **68, 69, 70, 71, 72**) are similar to those in the mesothorax (Fig. 3, **48, 49, 50, 51, 52**) respectively, except that the second and fifth (Fig. 3, **69, 72**) are shorter than those in the mesothorax (Fig. 3, **49, 52**) and are attached dorsally on the lateral portion of the anterior end of the following tergum.

5) Coxal and Trochanteral Muscles

The coxal and trochanteral muscles (Fig. 3, **73, 74, 75, 76, 77, 78, 79, 80, 81**) are similar to those in the mesothorax (Fig. 3, **53, 54, 55, 56, 57, 58, 59, 60, 61**) respectively, though the dorsal attached positions of the former are situated on the more anterior portion of the tergum than those in the latter.

e. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 3 and Table I.

2. COLLEMBOLA

A. Poduridae

Neannra dubiosa RITTER (Fig. 4)

a. Head Musculature

1) Labral Muscles

Two labral muscles are found on each side: One (Fig. 4, **1**) arising on the dorsal portion of the head immediately lateral to the most anterior verruca of the head, the other (Fig. 4, **2**) arising on the dorsolateral portion of the transverse ridge of the head (the intersegmental ridge between the maxillary and labial segments?), and both are attached on the lateral basal portion of the labrum.

2) Antennal Muscles

Six muscles are attached on the antenna: Two muscles (Fig. 4, **3, 4**) arising on the tendinous tentorial plate and attached on the dorsal basal rim of the scape; two muscles (Fig. 4, **5, 6**) arising on the tendinous tentorial plate and inserted into the ventral basal rim of the scape; a muscle (Fig. 4, **7**) arising on the frontal region and inserted into the dorsal rim of the pedicel; a muscle (Fig. 4, **8**) originated on the frontal region and attached on the ventral basal rim of the pedicel.

3) Mandibular Muscles

Four muscles are attached on the mandible: A muscle (Fig. 4, **9**) arising on the lateral portion of the head and attached on the anterior basal rim of the mandible; a muscle (Fig. 4, **10**) arising on the inner base of the labial appendage and attached on the lateral basal rim of the mandible; a muscle (Fig. 4, **11**) originated on the tendinous tentorial plate and attached on the lateral basal rim of the mandible; a muscle (Fig. 4, **12**) arising on the tentorial plate and inserted into the lateral wall of the mandible.

4) Maxillary Muscles

Two muscles are attached on the base of the maxilla, one (Fig. 4, **13**) arising on the latero-posterior portion of the head (probably la-

bial tergum) and attached on the median basal rim of the maxilla, the other (Fig. 4, **14**) originating on the tentorial plate and attached on the lateral basal rim of the maxilla.

5) **Muscles of the Labial Segment**

On each side of the labial segment are found seven muscles: Two longitudinal dorsal muscles (Fig. 4, **15, 16**) attached anteriorly on the dorsal transverse ridge of the head (the intersegmental ridge between the maxillary and labial segments?) and posteriorly on the dorsal intersegmental ridge between the labial and prothoracic segments; a ventral muscle (Fig. 4, **17**) arising on the tentorial and attached on the ventro-lateral region of the segment; two muscles of the labial appendage, one (Fig. 4, **18**) arising on the tentorial plate, the other (Fig. 4, **19**) arising on the latero-ventral portion of the intersegmental ridge between the pro- and mesothorax, and both attached on the median base on the labial appendage; two tergo-sternal muscles, one (Fig. 4, **20**) arising on the anterior end of the dorso-lateral region of the tergal region and attached on the latero-ventral portion of the intersegmental fold between the labial and prothoracic segments, the other (Fig. 4, **21**) arising on the lateral portion of the head (probably the tergal region of the labial segment) and attached on the tentorial plate.

b. Prothoracic Musculature

1) **Dorsal Muscles**

Two longitudinal dorsal muscles are observed on each side, a median (Fig. 4, **22**) and a lateral (Fig. 4, **23**), both are stretched between the anterior and posterior ends of the tergum.

2) **Ventral Muscles**

Three ventral muscles are observed on each side: One (Fig. 4, **24**) attached anteriorly on the median anterior end of the sternum between the connectives of the ventral nerve cord and posteriorly on the ventro-lateral portion of the intersegmental ridge at the posterior end of the segment; the other (Fig. 4, **25**) arising on the lateral por-

tion of the sternum near the inside of the subcoxa and attached on the postero-median portion of the sternum; still an other (Fig. 4. 26) originated on the sternum inside the subcoxal ring as the preceding muscle and attached on the lateral portion of the posterior end of the sternum.

3) **Tergo-Sternal Muscles**

Five tergo-sternal muscles are found on each side: The first (Fig. 4, 27) arising on the dorso-lateral portion of the anterior end of the tergum and attached on the median anterior end of the sternum between the connectives of the ventral nerve cord; the second (Fig. 4, 28) stretched between the dorso-lateral portion and the ventro-lateral portion at the anterior end of the segment; the third (Fig. 4, 29) arising on the dorsal portion of the posterior end of the segment near the dorsal median line and attached on the ventro-lateral portion of the anterior end of the segment; the fourth (Fig. 4, 30) arising on the dorso-lateral portion of the anterior end of the segment, the fifth (Fig. 4, 31) originating on the anterior of the lateral portion of the tergal region, both attached on the ventro-lateral portion of the posterior end of the segment.

4) **Coxal Muscles**

Seven muscles are attached on the coxa: A tergal promotor (Fig. 4, 32) arising on the dorso-lateral portion of the anterior end of the segment and attached on the anterior basal rim of the coxa; two sternal promotors, one (Fig. 4, 33) originating on the median anterior end of the sternum and attached on the antero-lateral basal wall of the coxa, the other (Fig. 4, 34) arising on the ventro-lateral portion of the posterior end of the segment and inserted into the anterior basal rim of the coxa; two tergal remotors, one (Fig. 4, 35) attached dorsally on the posterior end of the dorso-lateral region of the tergum and ventrally on the posterior basal rim of the coxa, the other (Fig. 4, 36) arising on the tergum anterior to the preceding muscle, and attached on the postero-lateral basal margin of the coxa; a sternal remotor (Fig. 4, 37) arising on the ventro-lateral portion of the posterior end of the segment and inserted into the postero-lateral basal

wall of the coxa; a tergal abductor (Fig. 4, **38**) taking its rise on the anterior portion of the dorso-lateral region of the tergum and its insertion into the lateral basal wall of the coxa.

5) **Trochanteral Muscles Arising on the Thorax**

A pair of sternal depressors of the trochanters (Fig. 4, **39**) arise on the ventro-lateral portions of the posterior end of the segment and are attached on the ventral bases of the trochanters.

c. Mesothoracic Musculature

1) **Dorsal Muscles**

The dorsal muscles (Fig. 4, **40, 41**) are very similar to those in the prothorax (Fig. 4, **22, 23**).

2) **Dorsal Transverse Muscles**

A pair of very delicate dorsal transverse muscles arise on the dorso-lateral portions of the anterior end of the tergum, and are attached on the dorsal vessel (Fig. 4, **42**).

3) **Ventral Muscles**

Three ventral muscles are found on each side, one (Fig. 4, **43**) stretched between the ventro-lateral portions of both ends of the segment, two others (Fig. 4, **44, 45**) very similar to the ventral muscles in the prothorax (Fig. 4, **27, 28**) respectively.

4) **Ventral Transverse Muscles**

A pair of very slender muscles (Fig. 4, **46**) arise on the lateral portions of the anterior end of the sternal region and are attached on the median anterior end of the sternal region.

5) **Tergo-Sternal Muscles**

Five tergo-sternal muscles are found on each side: The first (Fig. 4, **47**) arises on the antero-lateral portion of the tergum, the second (Fig. 4, **48**) on the dorso-lateral region of the tergum outside the median verruca, the third (Fig. 4, **49**) on the tergum outside the second along the inner base of the dorso-lateral verruca, the fourth (Fig. 4, **50**) on the posterior end of the tergum near the median line, the fifth (Fig. 4, **51**) on the posterior end of the dorso-lateral region

of the tergum outside the fourth, and all these are attached on the ventro-lateral portion of the anterior end of the segment.

6) Coxal Muscles

Eight muscles are attached on the base of the coxa: Two tergal promotors, one (Fig. 4, **52**) arising on the dorso-lateral region of the tergum behind the dorso-lateral verruca, the other (Fig. 4, **53**) on the tergum behind the preceding muscle, and both are attached on the anterior basal rim of the coxa; two sternal promotors, one (Fig. 4, **54**) similar io the first sternal promotor in the prothorax (Fig. 4, **33**), the other (Fig. 4, **55**) arising on the ventro-lateral portion of the anterior end of the segment and attached on the anterior basal rim of the coxa; two tergal remotors (Fig. 4, **56, 57**), a sternal remotor (Fig. 4, **58**) and a tergal abductor (Fig. 4, **59**) very similar to those in the prothorax (Fig. 4, **35, 36, 37, 38**) respectively.

7) Trochanteral Muscles Arising on the Thorax

A pair of sternal depressors (Fig. 4, **60**) very similar to those in the prothorax (Fig. 4, **39**) are found on the mesothorax.

d. Metathoracic Musculature

The metathoracic musculature is very similar to the mesothoracic. The metathoracic muscles correspond to the mesothoracics respectively as follows: the dorsal muscles (Fig. 4, **61, 62**) to (Fig. 4, **40, 41**); the dorsal transverse muscle (Fig. 4, **63**) to (Fig. 4, **42**); the ventral muscles (Fig. 4, **64, 65, 66**) to (Fig. 4, **43, 44, 45**); the ventral transverse muscle (Fig. 4, **67**) to (Fig. 4, **46**); the tergo-sternal muscles (Fig. 4, **68, 69, 70, 71, 72**) to (Fig. 4, **47, 48, 49, 50, 51**); the coxal and trochanteral muscles (Fig. 4, **73, 74,75, 76, 77, 78, 79, 80, 81**) to (Fig. 4, **52, 53, 54, 55, 56, 57, 58, 59, 60**).

e. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 4 and Table I.

B. Entomobryidae

Folsomia sp. (Fig. 5)

a. Head Musculature

1) Antennal Muscles

On the base of the scape, three muscles are attached: One (Fig. 5, **1**) arising on the cranial wall behind the antennal base and inserted into the dorsal basal rim of the scape, the other (Fig. 5, **2**) on the tentorial plate and into the ventral inner basal rim of the scape, still an other (Fig. 5, **3**) on the tentorial plate and into the ventro-lateral basal rim of the scape. The muscles attached on the flagellum were not observed.

2) Mandibular Muscles

Four muscles attach on the base of the mandible: The first (Fig. 5, **4**) arising on the lateral portion of the head, the second (Fig. 5, **5**) on the postero-dorsal portion of the head, and both are attached on the inner basal rim of the mandible; the third (Fig. 5, **6**) originating on the postero-dorsal portion of the head behind the second and inserted into the lateral basal rim of the mandible; the fourth (Fig. 5, **7**) arising on the tentorial plate and attached on the inner basal rim of the mandible.

3) Maxillary Muscles

Four muscles are found on the maxilla: The first (Fig. 5, **8**) originating on the lateral wall of the cranium and inserted into the inner base of the lacinia; the second (Fig. 5, **9**) on the tentorial plate and into the lateral basal rim of the maxilla; the third and fourth (Fig. 5, **10, 11**) on the lateral basal wall of the maxilla and into the inner base of the lacinia.

4) Labial Muscles

Two muscles are found on each side of the labial region, one (Fig. 5, **12**) arising on the tentorial plate and inserted into the ventral region of the head behind the labial appendage, the other (Fig. 5, **13**) on the tentorial plate and into the median base of the labial appendage.

5) Tergo-Sternal Muscles of the Head

Two tergo-sternal muscles are found on each side, one (Fig. 5, **14**) arising on the dorsal portion of the cranium behind the antennal base, the other (Fig. 5, **15**) on the cranial wall behind the preceding muscle, and both are attached on the tentorial plate.

b. Prothoracic Musculature

1) Dorsal Muscles

Two dorsal muscles, a median longitudinal (Fig. 5, **16**) and a lateral longitudinal (Fig. 5, **17**), arise on the cranial wall before the second mandibular muscle and are attached on the anterior end of the mesotergum. These are found on each side.

2) Ventral Muscles

The ventral muscles are two-paired, one pair of longitudinal ventral muscles (Fig. 5, **18**) are attached anteriorly on the tentorial plate of the head and posteriorly on the ventro-lateral portions of the anterior end of the mesothorax, and the other (Fig. 5, **19**) arise on the middle of the median region of the sternum and are attached on the lateral portions of the sternum near the insides of the leg bases.

3) Tergo-Sternal Muscles

Two tergo-sternal muscles are found on each side, one (Fig. 5, **20**) originates on the dorso-lateral portion of the posterior end of the head and is attached on the lateral portion of the sternum near the inside of the leg base, the other (Fig. 5, **21**) arises on the anterior end of the dorso-lateral region of the mesotergnm and is attached on the tentorial plate.

4) Coxal Muscles

Seven muscles are attached on the base of the coxa: A tergal promotor (Fig. 5, **22**) originates on the posterior portion of the dorso-lateral region of the head and is attached on the anterior basal rim of the coxa; two sternal promotors, one (Fig. 5, **23**) arises on the tentorial plate and is inserted into the antero-lateral basal wall of the coxa, the other (Fig. 5, **24**) on the lateral portion of the sternum

inside the leg base and into the anterior basal rim of the coxa; a tergal remotor (Fig. 5, **25**) taking its origin on the anterior portion of the dorso-lateral region of the mesotergum is inserted into the posterior basal rim of the coxa; two sternal remotors, one (Fig. 5, **26**) attached on the postero-lateral basal wall of the coxa, the other (Fig. 5, **27**) on the posterior basal rim of the coxa, both originate on the lateral portion of the sternum inside the leg base; a tergal abductor (Fig. 5, **28**) arising on the anterior portion of the dorso-lateral region of the mesotergum and attached on the lateral base of the coxa.

5) Trochanteral Muscles Arising on the Thorax

A pair of slender sternal depressors (Fig. 5, **29**) of the trochanters arise on the lateral portions of the sternum inside the leg bases, and are attached on the ventral bases on the trochanters.

c. Mesothoracic Musculature

1) Dorsal Muscles

The dorsal muscles are three-paired: The first pair (Fig. 5, **30**) are median longitudinal muscles arising on the anterior portion of the median region of the tergum and are attached on the median anterior end of the first abdominal tergum; the second pair (Fig. 5, **31**) are median longitudinal muscles stretched between the anterior ends of the meso- and metatergum outside the first; the third pair (Fig. 5, **32**) are lateral longitudinal muscles stretched between the anterior ends of the dorso-lateral regions of the meso- and metatergum.

2) Dorsal Transverse Museles

A pair of delicate dorsal transverse muscles arise on the dorso-lateral portions of the anterior end of the tergum and are attached on the dorsal vessel (Fig. 5, **33**)

3) Ventral Muscles

Four ventral muscles are found on each side: A thick longitudinal muscle (Fig. 5, **34**) stretched between the ventro-lateral portions of the anterior ends of the meso- and metathorax; a very small mus-

cle (Fig. 5, **35**) similar to the second ventral muscle of the prothorax; an anterior muscle (Fig. 5, **36**) arising on the antero-laterel portion of the sternum and inserted into the middle of the lateral portion of the sternum inside the leg base; a posterior muscle (Fig. 5, **37**) arising on the postero-lateral portion of the sternum and inserted into the middle of the lateral portion of the sternum.

4) **Ventral Transverse Muscles**

A pair of very slender ventral transverse muscles (Fig. 5, **38**) very similar to the ventral transverse muscles in the *Neanura* (Fig. 4, **46**) are found on the anterior end of the segment.

5) **Tergo-Sternal Muscles**

Four tergo-sternal muscles are found on each side: The first (Fig. 5, **39**) arising on the portion more or less anterior to the middle of the dorso-lateral region of the tergum, the second (Fig. 5, **40**) on the dorso-lateral region of the tergum behind the first, and the third (Fig. 5, **41**) on the anterior end of the dorso-lateral region of the metatergum. These three are attached on the ventro-lateral portion of the anterior end of the segment. The fourth (Fig. 5, **42**) arises on the middle of the lateral region of the tergum and is inserted into the middle of the lateral portion of the sternum inside the leg base.

6) **Coxal Muscles**

Nine muscles are attached on the base of the coxa: Two tergal promotors, one (Fig. 5, **43**) originating on the anterior portion of the dorso-lateral region of the tergum by a wide base, the other (Fig. 5, **44**) on the middle of the dorso-lateral region of the tergum, both are attached on the anterior basal rim of the coxa; three sternal promotors, one (Fig. 5, **45**) attached on the antero-lateral base of the coxa, the other (Fig. 5, **46**) on the antero-lateral wall of the coxa, both arise on the antero-lateral portion of the sternum, still an other (Fig. 5, **47**) similar to the second sternal promotor in the prothorax (Fig. 5, **24**); a tergal remotor (Fig. 5, **48**) arising on the portion more or less posterior to the middle of the dorso-lateral portion of the tergum and attached on the posterior basal rim of the coxa; two sternal remotors

(Fig. 5, **49, 50**) and a tergal abductor (Fig. 5, **51**) very similar to those in the prothorax (Fig. 5, **26, 27, 28**) respectively.

7) Trochanteral Muscles Arising on the Thorax

The trochanteral muscles (Fig. 5, **52**) are very similar to those in the prothorax (Fig. 5, **29**).

d. Metathoracic Musculature

The metathoracic musculature well-resembles the mesothoracic. The dorsal muscles (Fig. 5, **53, 54, 55**), the dorsal transverse muscle (Fig. 5, **56**), the ventral muscles (Fig. 5, **57, 58, 59, 60**), the ventral transverse muscle (Fig. 5, **61**), the tergo-sternal muscles (Fig. 5, **62, 63, 64, 65**), the coxal muscles (Fig. 5, **66, 67, 68, 69, 70, 71, 72, 73, 74**) and the trochanteral muscle (Fig. 5, **75**) correspond to the mesothoracic muscles (Fig. 5, **30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52**) respectively.

e. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 5 and Table I.

3. COMPARISON OF THE THORACIC MUSCLES IN APTERYGOTE INSECTS

The thoracic muscles in apterygote insects would be compared as in the following table.

TABLE I

Thoracic Musculature in Apterygote Insects

(The nonbracketted numerals show the number of the muscles. The bracketted numerals are signs used in the figures. " — " shows the absence of muscles.)

a) Prothoracic Musculature

	Thysanura						Collembola			
	Machilidae. *Pedetontus* sp. (Fig. 1)		Lepismidae. *Lepisma saccharina* (Fig. 2)		Campodeidae. *Lepidocampa weberi* (Fig. 3)		Poduridae. *Neanura dubiosa* (Fig. 4)		Entomobryidae. *Folsomia* sp. (Fig. 5)	
Dorsal Muscles.	2	(1) (2)	7	(1) (2) (3) (4) (5) (6) (7)	3	(25) (26) (27)	2	(22) (23)	2	(16) (17)
Ventral Muscles.	3	(3) (4) (5)	3	(8) (9) (10)	2	(28) (29)	3	(24) (25) (26)	2	(18) (19)
Ventral Transverse Muscles.	—		1	(11)						
Tergo-Sternal Muscles.	4	(6) (7) (8) (9)	6	(12) (13) (14) (15) (16) (17)	5	(30) (31) (32) (33) (34)	5	(27) (28) (29) (30) (31)	2	(20) (21)
Tergo-Pleural Muscles.	2	(10) (11)	3	(18) (19) (20)	—		—		—	
Sterno-Pleural Muscles.	—		1	(21)	—		—		—	
Coxal Muscles.										
Tergal promotor.	1	(12)	1	(22)	1	(35)	1	(32)	1	(22)
Sternal promotor.	2	(15) (16)	1	(26)	1	(36)	2	(33) (34)	2	(23) (24)
Tergal remotor.	2	(13) (14)	3	(23) (24) (25)	4	(37) (38) (39) (40)	2	(35) (36)	1	(25)
Sternal remotor.	1	(17)	2	(27) (28)	1	(41)	1	(37)	2	(26) (27)
Tergal abductor.	3	(18) (19) (20)	—		1	(42)	1	(38)	1	(28)
Pleural abductor.	—		1	(29)	—		—		—	
Trochanteral Muscles.										
Tergal depressor.	1	(21)	1	(30)	—		—		—	
Pleural depressor.	—		1	(31)	—		—		—	
Sternal depressor.	1	(22)	1	(32)	1	(43)	1	(39)	1	(29)

b) Mesothoracic Musculature

	Thysanura						Collembola			
	Machilidae. *Pedetontus* sp. (Fig. 1)		Lepismidae. *Lepisma saccharina* (Fig. 2)		Campodeidae. *Lepidocampa weberi* (Fig. 3)		Poduridae. *Neanura dubiosa* (Fig. 4)		Entomobryidae. *Forsomia* sp. (Fig. 5)	
Dorsal Muscles.	2	(23) (24)	5	(33) (34) (35) (36) (37)	2	(44) (45)	2	(40) (41)	3	(30) (31) (32)
Dorsal Transverse Muscles.	—		1	(38)	—		1	(42)	1	(33)
Ventral Muscles.	3	(25) (26) (27)	3	(39) (40) (41)	2	(46) (47)	3	(43) (44) (45)	4	(34) (35) (36) (37)
Ventral Transverse Muscles.	1	(28)	2	(42) (43)	—		1	(46)	1	(38)
Tergo-Sternal Muscles.	7	(29) (30) (31) (32) (33) (34) (35)	5	(44) (45) (46) (47) (48)	5	(48) (49) (50) (51) (52)	5	(47) (48) (49) (50) (51)	4	(39) (40) (41) (42)
Tergo-Pleural Muscles.	2	(36) (37)	3	(49) (50) (51)	—		—		—	
Sterno-Pleural Muscles.	2	(38) (39)	1	(52)	—		—		—	
Coxal Muscles.										
Tergal promotor.	1	(40)	2	(53) (54)	1	(53)	2	(52) (53)	2	(43) (44)
Sternal promotor.	1	(43)	1	(58)	1	(54)	2	(54) (55)	3	(45) (46) (47)
Tergal remotor.	2	(41) (42)	3	(55) (56) (57)	4	(55) (56) (57) (58)	2	(56) (57)	1	(48)
Sternal remotor.	1	(44)	2	(59) (60)	1	(59)	1	(58)	2	(49) (50)
Tergal abductor.	1	(45)	—		1	(60)	1	(59)	1	(51)
Pleural abductor.	—		1	(61)	—		—		—	
Trochanteral Muscles.										
Tergal depressor.	—		1	(62)	—		—		—	
Pleural depressor.	1	(46)	3	(63) (64) (65)	—		—		—	
Sternal depressor.	—		1	(66)	1	(66)	1	(60)	1	(52)
Muscles of the Spiracle.	—		1	(67)	—		—		—	

c) Metathoracic Musculature

	Thysanura			Collembola	
	Machilidae. *Pedetontus* sp. (Fig. 1)	Lepismidae. *Lepisma saccharina* (Fig. 2)	Campodeidae. *Lepidocampa weberi* (Fig. 3)	Poduridae. *Neanura dubiosa* (Fig. 4)	Entomobryidae. *Forsomia* sp. (Fig. 5)
Dorsal Muscles.	2 (47) (48)	5 (68) (69) (70) (71) (72)	3 (62) (63) (64)	2 (61) (62)	3 (53) (54) (55)
Dorsal Transverse Muscles.	—	1 (73)	1 (65)	1 (63)	1 (56)
Ventral Muscles.	2 (49) (50)	3 (74) (75) (76)	2 (66) (67)	3 (64) (65) (66)	4 (57) (58) (59) (60)
Ventral Transverse Muscles.	1 (51)	2 (77) (78)	—	1 (67)	1 (61)
Tergo-Sternal Muscles.	7 (52) (53) (54) (55) (56) (57) (58)	5 (79) (80) (81) (82) (82a)	5 (68) (69) (70) (71) (72)	5 (68) (69) (70) (71) (72)	4 (62) (63) (64) (65)
Tergo-Pleural Muscles.	2 (59) (60)	3 (83) (84) (85)	—	—	—
Sterno-Pleural Muscles.	5 (61) (62)	1 (86)	—	—	—
Coxal Muscles.					
Tergal promotor.	1 (63)	2 (87) (88)	1 (73)	2 (73) (74)	2 (66) (67)
Sternal promotor.	1 (96)	1 (92)	1 (74)	2 (75) (76)	3 (68) (69) (70)
Tergal remotor.	2 (64) (65)	3 (89) (90) (91)	4 (75) (76) (77) (78)	2 (77) (78)	1 (71)
Sternal remotor.	1 (67)	2 (93) (94)	1 (79)	1 (79)	2 (72) (73)
Tergal abductor.	1 (68)	—	1 (80)	1 (80)	1 (74)
Pleural abductor.	—	1 (95)	—	—	—
Trochanteral Muscles.					
Tergal depressor.	—	1 (96)	—	—	—
Pleural depressor.	1 (69)	3 (97) (98) (99)	—	—	—
Sternal depressor.	—	1 (100)	1 (81)	1 (81)	1 (75)
Muscles of the Spiracle.	—	1 (101)	—	—	—

d) Musculatures of the Anterior Abdominal Segments

	Thysanura			Collembola	
	Machilidae. *Pedetontus* sp. (Fig. 1)	Lepismidae. *Lepisma saccharina* (Fig. 2)	Campodeidae. *Lepidocampa weberi* (Fig. 3)	Poduridae. *Neanura dubiosa* (Fig. 4)	Entomobryidae. *Forsomia* sp. (Fig. 5)
I Abd. Segm.					
Dorsal Muscles.	5 (70) (71) (72) (73) (74)	7 (102) (103) (104) (105) (106) (107) (108)	3 (82) (83) (84)	2 (82) (83)	3 (76) (77) (78)
Dorsal Transverse Muscles.	(not observed)	1 (109)	1 (85)	1 (84)	1 (79)
Ventral Muscles.	3 (75) (76) (77)	4 (110) (111) (112) (113)	2 (86) (87)	2 (85) (86)	3 (80) (81) (82)
Ventral Transverse Muscles.	1 (78)	1 (114)	—	1 (87)	1 (83)
Tergo-Sternal Muscles.	7 (79) (80) (81) (82) (83) (84) (85)	2 (115) (116)	2 (88) (89)	4 (88) (89) (90) (91)	3 (84) (85) (86)
Tergo-Pleural Muscles.	—	—	—	2 (92) (93)	—
Sterno-Pleural Muscles.	—	—	—	1 (94)	—
Muscles of the Stylus.	—	—	1 (90)	—	—
Muscles of the Retractile Vesicl.	2 (86) (87)	—	—	—	—
II Abd. Segm.					
Dorsal Muscles.	5 (70) (71) (72) (73) (74)	6 (117) (118) (119) (120) (121) (122)	3 (91) (92) (93)	2 (95) (96)	3 (87) (88) (89)
Dorsal Transverse Muscles.	(not observed)	1 (123)	1 (94)	1 (97)	1 (90)
Ventral Muscles.	3 (75) (76) (77)	2 (124) (125)	2 (95) (96)	1 (98)	2 (91) (92)
Ventral Transverse Muscles.	1 (78)	1 (126)	—	1 (99)	1 (93)
Tergo-Sternal Muscles.	7 (79) (80) (81) (82) (83) (84) (85)	3 (124) (128) (129)	3 (97) (98) (99)	4 (100) (101) (102) (103)	3 (94) (95) (96)
Tergo Pleural Muscles.	—	—	—	3 (104) (105) (106)	—
Sterno-Pleural Muscles.	—	—	—	1 (107)	—
Muscles of the Stylus.	1 (88)	—	1 (100)	—	—
Muscles of the Retractile Vesicle.	2 (86) (87)	—	2 (101) (102)	—	—

ii. PTERYGOTA

1. ORTHOPTERA

Blattidae.	*Periplaneta australasiae* LINNAEUS (Fig. 6)
Mantidae.	*Hierodula patellifera* SERVILLE (Fig. 7)
Phasmidae.	*Megacrania tsudai* SHIRAKI (MAKI, 1935)
Acridiidae.	*Locusta migratoria manilensis* MEYEN (Fig. 8)
	Atractomorpha ambigua BOLIVAR (Fig. 9)
Tettigonidae.	*Xiphidion maculatum* GUILLON (Fig. 10)
Gryllidae.	*Brachytrupes portentosus* LICHTENSTEIN (Fig. 11)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has median dorsal, lateral dorsal and anterior dorsal muscles.

The median dorsal muscles in *Periplaneta australasiae* (Fig. 6), *Hierodula patellifera* (Fig. 7), *Locusta migratoria manilensis* (Fig. 8) and *Atractomorpha ambigua* (Fig. 9) are divisible into two kinds, long and short dorsal muscles. In *Megacrania tsudai*, *Xiphidion maculatum* (Fig. 10) and *Brachytrupes portentosus* (Fig. 11) there are only the median long dorsal muscles, lacking the short median dorsal ones.

The median long dorsal muscles (Figs. 6, 7, 8, 9, 10, 11, **1**) are the longest in the dorsal muscles and slightly fan-shaped or uniformly thickened in general, excepting of *H. patellifera* spindle-shaped, attached anteriorly on the dorso-lateral portions of the posterior end of the head and posteriorly on the first phragmata, or on the apices of the anterior special elongations of the first phragmata in the *Hierodula* (Fig. 7, **1**).

The short or external median dorsal muscles in the *Periplaneta* (Fig. 6, **2**), *Hierodula* (Fig. 7, **2**) and *Locusta* (Fig. 8, **2**) are attached anteriorly on the cervical dorsal membrane, and posteriorly on the first phragmata externally to the long median dorsal muscles. The short median dorsal muscles in the *Atractomorpha* (Fig. 9, **2**) arise on the anterior median region of the protergum near the anterior transverse ridge of the tergum and are inserted into the first phragmata externally to the long median dorsal muscles as in the cases of the *Periplaneta* and *Locusta*.

The lateral dorsal muscles are oblique and short, arising on the protergum and attached on the lateral portions of the anterior end of the mesotergum. The muscles of the *Periplaneta* (Fig. 6), *Hierodula* (Fig. 7), *Megacrania*, *Locusta* (Fig. 8), *Atractomorpha* (Fig. 9), and *Xiphidion* (Fig. 10) are in two pairs, internal and external. In the *Periplaneta*, the internal lateral dorsal muscle (Fig. 6, **3**) arises on the central region of the protergum, and the external one (Fig 6, **4**) is very broadly fan-shaped and arises on the posterior side of the internal one. In the mantid, the internal lateral dorsal muscle (Fig. 7, **3**) is very thick and arises on tne posterior median portion of the protergum, the external one (Fig. 7, **4**) is fan-shaped, longitudinal and somewhat longer than the internal one. In the phasmid there are found two internal and two external lateral dorsal muscles. In the Acridiidae, the internal lateral dorsal muscle (Figs. 8, 9, **3**) is very often subdivided into two bundles and arises on the anterior transverse ridge of the protergum, the external one (Figs. 8, 9, **4**) is slender and arises on the second transverse ridge of the protergum behind the internal one. In the *Xiphidion*, the internal lateral dorsal muscle (Fig. 10, **2**) is long and fan-shaped, and arises on the anterior median portion of the protergum, the external one (Fig. 10, **3**) is shorter than the internal, fan-shaped, and arises on the central portion of the protergum along the dorsal median line. In the *Brachytrupes* is found a lateral dorsal muscle (Fig. 11, **2**) on each side, and it is fan-shaped and originates on the posterior median portion of the protergum.

The anterior dorsal muscles are one-paired in the *Periplaneta* (Fig. 6), *Atractomorpha* (Fig. 9), *Brachytrupes* (Fig. 11), and two-paired in the *Hierodula* (Fig. 7), *Megacrania*, *Locusta* (Fig. 8) and *Xiphidion* (Fig. 10). Those muscles are generally oblique and fan-shaped, attached anteriorly on the dorso-lateral portion of the posterior end of the head and posteriorly on the median dorsal region of the segment, but the posterior attached positions of the muscles vary in different species as follows: In the *Periplaneta* (Fig. 6, **5**) attached on the cervical dorsal sclerite, in the *Locusta* (Fig. 8, **5, 6**) and *Atractomorpha*

(Fig. 9, **5**) on the anterior portion of the protergum, and in the *Brachytrupes* (Fig. 11, **3**) on the posterior portion of the protergum; in the *Hierodula* the first pair are attached on the antero-median portion of the protergum (Fig. 7, **5**), the second pair on the dorso-lateral portions of the anterior region of the protergum (Fig. 7, **6**); in the *Megacrania* and *Xiphidion* (Fig. 10, **4**, **5**) the first pair are attached on the an- terior end of the protergal plate, and the second pair on the central region of the protergal plate.

2) **Ventral Muscles**

In the Orthoptera there are found long longitudinal or internal ventrals, short longitudinal or external ventrals, cruciate ventrals and anterior ventrals, but the muscles except the first are not always present in all the species.

The long longitudinal or internal ventrals (Fig. 6, **6**; Fig. 7, **7**; Fig. 8, **7**; Fig. 9, **6**; Fig. 10, **6**; Fig. 11, **4**) are one-paired, long and very thick, arising on the posterior bases of the posterior tentorial arms and attached posteriorly on the profurcal arms.

The short or external longitudinal ventral muscles are one-paired in the *Periplaneta* (Fig. 6, **7**), *Megacrania* and *Brachytrupes* (Fig. 11, **5**), two-paired in the *Locusta* (Fig. 8, **8**, **9**) and *Atractomorpha* (Fig. 9, **7**, **8**), but lack in the *Hierodula* (Fig. 7) and *Xiphidion* (Fig. 10). The external longitudinal ventral muscles in the blattid and phasmid arise anteriorly on the posterior ends of the ventrolateral cervical sclerites, those in the locusts (Fig. 8, **8**, **9**; Fig. 9, **7**, **8**) and the cricket (Fig. 11, **5**) arise on the cervical ventral membranes. All these attach posteriorly on the profurcal arms.

The cruciate ventral muscles are found in one pair on only the Acridiidae (Fig. 8, **10**; Fig. 9, **9**). Each muscle arises anteriorly on the anterior portion of the ventro-lateral cervical sclerite, passes the upper side of the long longitudinal ventral muscle, and is attached posteriorly on the profurcal arm of the opposite side.

The anterior ventral muscles are found on the *Locusta* (Fig. 8, **11**), *Atractomorpha* (Fig. 9, **10**), *Xiphidion* (Fig. 10, **7**) and *Brachytrupes* (Fig. 11, **6**). These are very small, arise on the posterior sides

of the posterior tentorial arms and attach on the anterior portions of the ventro-lateral cervical sclerites.

3) **Ventral Transverse Muscles**

The ventral transverse muscles are one-paired, very small, stretched between the profurcal arms and the spina of the posterior end of the prosternal region. These muscles are found on the *Periplaneta* (Fig. 6, 8), *Locusta* (Fig. 8, **12**), *Xiphidion* (Fig. 10, 8) and *Brachytrupes* (Fig. 11, 7), but are lacking in the *Hierodula*, *Megacrania* and *Atractomorpha*.

4) **Tergo-Sternal Muscles**

Four kinds of tergo-sternal muscles are observed in the Orthoptera: anterior intersegmental tergo-sternals, anterior internal tergo-sternals, external tergo-sternals, and posterior tergo-sternals. The anterior intersegmental tergo-sternals are thick, attached anteriorly on the dorso-lateral portions of the posterior end of the head and posteriorly on the ventro-lateral cervical sclerites. These are two-paired in the *Periplaneta* (Fig. 6, **9, 10**), *Megacrania*, *Locusta* (Fig. 8, **13, 14**), *Atractomorpha* (Fig. 9, **11, 12**) and *Xiphidion* (Fig. 10, **9, 10**), and one-paired in the *Hierodula* (Fig. 7, 8) and *Brachytrupes* (Fig. 11, 8). The attachdd positions of the muscles on the ventro-lateral cervical sclerites vary in different species: The muscles in *Periplaneta* and *Hierodula* are attached on the anterior subdivisions of the ventro-lateral cervical sclerites; in those of the *Locusta* and *Atractomorpha*, the first pair attach on the anterior subdivisions of the ventro-lateral cervical sclerites, and the second pair on the posterior subdivisions of the ventro-lateral cervical sclerites; the muscles in the *Xiphidion* and *Brachytrupes* attach on the middle or slightly posterior portions of the undivided ventro-lateral cervical sclerites.

The anterior internal tergo-sternals are bundles of fibers situated on the insides of the anterior intersegmental tergo-sternals and connecting the anterior portions of the protergum with the ventro-lateral cervical sclerites. The muscles are three-paired in the *Periplaneta* (Fig. 6, **11, 12, 13**) and *Hierodula* (Fig. 7, **9, 10, 11**), and two-paired in the *Megacrania*, *Locusta* (Fig. 8, **15, 16**), *Atractomorpha* (Fig. 9,

13, 14), *Xiphidion* (Fig. 10, **11, 12**) and *Brachytrupes* (Fig. 11, **9, 10**). In the attached positions of the muscles on the cervical sclerites there are two forms: one found on the *Periplaneta* and *Brachytrupes*, the attached positions of the muscles are situated on the posterior subdivisions or posterior halves of the ventro-lateral cervical sclerites; the other found on the *Hierodula*, *Megacrania*, *Locusta*, *Atractomorpha* and *Xiphidion*, the muscles attach on the anterior subdivisions or anterior halves of the ventro-lateral cervical sclerites, exceptionally the first pair of the muscles of the *Hierodula* (Fig. 7, **9**) are attached on the lateral ends of the anterior ventral cervical sclerite.

The anterior external tergo-sternals are found on the *Megacrania* and *Brachytrupes*. Those in the first species are one-paired, attached ventrally on the lateral portions of the posterior subdivisions of the ventro-lateral cervical sclerites and dorsally on the postero-ventral sides of the thoracic glands. Those in the second species are two-paired (Fig. 11, **11, 12**), arising on the anterior portions of the ventro-lateral cervical sclerites, the first or inner pair are attached to the dorsal cervical sclerites and the second or outer pair on the latero-dorsal cervical sclerites.

The posterior tergo-sternals in the *Periplaneta* (Fig. 6, **14**), *Locusta* (Fig. 8, **17**), *Atractomorpha* (Fig. 9, **15**), *Xiphidion* (Fig. 10, **13**) and *Brachytrupes* (Fig. 11, **13**) are one-paired, and connect the antero-lateral corners of the mesotergum with the profurcal arms. Those in the *Hierodula* (Fig. 7, **12, 13**) and *Megacrania* (MAKI, 1935, Fig. 22, **78** described as a prothoracic sterno-pleural muscle, **101** described as a mesothoracic tergo-sternal muscle) are two-paired; in the former species the first pair of muscles are fan-shaped, strong, arising in the lateral regions of the posterior half of the prosternum and inserted into the apodemes on the intersegmental membrane anterior to the antero-lateral corners of the mesotergum, the second pair are strong, attached dorsally on the antero-lateral corners of the mesotergum and ventrally on the posterior end of the prosternum near the spina; in the latter species one pair (**78**) arise on the peritremes behind the first thoracic spiracles, the other (**101**) on the antero-lateral corners

of the mesotergum, and both attach on the postero-lateral corners of the prosternum.

5) **Tergo-Pleural Muscles**

The tergo-pleural muscles are divisible into two kinds, anterior tergo-pleurals and ordinary tergo-pleurals. The former are found in one pair on the *Locusta*, *Atractomorpha* and *Brachytrupes*; those of the first and second species (Fig. 8, **18**; Fig. 9, **16**) connect the dorso-lateral cervical membranes with the antero-dorsal corners of the propleura, and of the third species (Fig. 11, **14**) arise on both sides of the posterior end of the head and attach on the anterior portions of the propleura. The latter muscles are stretched between the protergum and the propleura, found on the *Periplaneta*, *Hierodula* and *Megacrania*; the muscles of the *Periplaneta* (Fig. 6, **15**) are one-paired, and very short, arising on the portions more or less anterior to the middle portions of the dorso-lateral areas of the protergum and inserted into the dorsal portions of the propleura; of the *Hierodula* (Fig. 7, **14**, **15**) are two-paired, the first pair arise about the middle portions of the dorso-lateral regions of the protergum and are inserted into the propleural arms, the second pair are very thick, arising on the anterior side of the first pair and inserted into the prothoracic epimera; of the *Megacrania* are broad, connecting the anterior lateral regions of the protergum with the dorsal marginal portions of the propleura. The ordinary tergo-pleural muscles in the *Locusta*, *Atractomorpha*, *Xiphidion* and *Brachytrupes* are obsolete, still their propleural arms are cemented to the protergum by tendinous matter.

6) **Sterno-Pleural Muscles**

The *Periplaneta* (Fig. 6, **16**), *Hierodula* (Fig. 7, **16**), *Locusta* (Fig. 8, **19**), *Xiphidion* (Fig. 10, **14**) and *Brachytrupes* (Fig. 11, **15**) have a pair of muscles which called furco-entopleural muscles, and connecting the propleural arms with the profurcal arms. The furco-entopleural muscles in the *Atractomorpha* (Fig. 9) are obsolete, the pleural arms and the furcal arms are, however, bridged by chitinous matter. The *Megacrania* has neither muscle nor chitinous bridge between the pleural arm and the furcal arm.

7) **Coxal Muscles**

(*a*) *Tergal Promotors.*

The tergal promotors are thick, attached dorsally on the tergum and ventrally on the trochantin near the coxal basal rim. Each coxa in the *Megacrania*, *Locusta* (Fig. 8, **20**), *Atractomorpha* (Fig. 9, **17**), *Xiphidion* (Fig. 7, **15**) and *Brachytrupes* (Fig. 11, **16**) has a tergal promotor, in the *Periplaneta* (Fig. 6, **17, 18, 19**) has three tergal promotors, and in the *Hierodula* (Fig. 7, **17, 18, 19, 20**) has four very thick tergal promotors. The rising positions of the muscles on the terga vary in different species: In the *Periplaneta*, the first and second tergal promotors (Fig. 6, **17, 18**) arise on the anterior median region of the tergum, and the third (Fig. 6, **19**) is thicker than the two others and arises on the portion more or less anterior to the middle of the dorso-lateral region of the tergum; in the *Hierodula*, the first tergal promotor (Fig. 7, **17**) arises on the median tergal region anterior to the transverse ridge of the tergum, the second (Fig. 7, **18**) on the median tergal region behind the transverse ridge of the tergum, the third (Fig. 7, **19**) on the outside of the second muscle, and the fourth (Fig. 7, **20**) on the median tergal region more posterior than the second; the muscle of the *Megacrania* arises on the median ridge of the tergum between the anterior and posterior transverse ridges of the tergum; the muscle in the *Locusta*, *Atractomorpha* and *Xiphidion* arises on the anterior portion of the dorso-lateral region of the tergum; the muscle of the *Brachytrupes* takes its origin on the dorso-lateral region of the tergum behind the pleural arm.

(*b*) *Pleural Promotors*

The *Megacrania* and *Atractomorpha* have a pleural promotor on each coxa, but the five other species lack the pleural promotor. The muscle of the *Megacrania* arises on the pleural ridge, of the *Atractomorpha* (Fig. 9, **18**) on the dorsal portion of the pleural arm attached to the tergal wall, and both are inserted into the apodeme on each trochantin.

(*c*) *Sternal Promotors*

The sternal promotors may be divided into two kinds, anterior cervical sternal promotors and posterior or ordinary sternal promotors. The anterior cervical sternal promotor is a muscle arising on the ventro-lateral cervical sclerite and inserted into the trochantin or the anterior basal rim of the coxa of the opposite side, it is, however, not always found on all the species. *Hierodula* (Fig. 7, **21**), *Xiphidion* (Fig. 10, **16**) and *Brachytrupes* (Fig. 11, **17**) have an anterior cervical sternal promotor on each coxa, and in the first species it is inserted into the trochantin, and in the two others it is inserted into the anterior coxal basal rim. The posterior or ordinary sternal promotors arise on the base of the profurcal arm and attach on the anterior basal rims of the coxae; these are found in one pair on the seven species (Fig. 6, **20**; Fig. 7, **22**; Fig. 8, **21**; Fig. 9, **19**; Fig. 10, **17**; Fig. 11, **18**).

(*d*) *Tergal Remotors*

The tergal remotors are bundles of fibers arising on the tergum and inserted into the posterior basal rim of the coxa. The *Periplaneta* (Fig. 6, **21, 22, 23**), *Megacrania*, *Locusta* (Fig. 8, **22, 23, 24**), *Atractomorpha* (Fig. 9, **20, 21, 22**), *Xiphidion* (Fig. 10, **18, 19, 20**) and *Brachytrupes* (Fig. 11, **19, 20, 21**) have three tergal remotors on each coxa, the first and second muscles are situated internally, arising on the middle or somewhat anterior of the dorso-lateral region of the tergum and attached on the posterior portion of the basal rim of the coxa, and the third muscle is an external bundle which has the origin and insertion on the outside of those of the two interiors. The *Hierodula* (Fig. 7, **23, 24, 25, 26, 27, 28**) has six remarkably developed tergal remotors on each coxa; the first, third and fifth are inner muscles, and the second, fourth and sixth are outer ones; the first arises on the posterior median region of the tergum, the third on the anterior side of the first, and the fifth on the anterior side of the third; the second muscle arises on the middle of the lateral region of the posterior subdivision of the tergum, the fourth on the anterior side of the second, and the sixth on the anterior side of the fourth; the first and second are inserted into the posterior basal rim of the coxa, the

third and fourth into the outside of the first and second, and the fifth and sixth into the latero-posterior portion of the basal rim of the coxa.

(*e*) *Sternal Remotors*

In the sternal remotors there are two kinds, posterior spinal remotors and ordinary sternal remotors. The posterior spinal remotors are muscles arising on both sides of the spina of the median posterior end of the sternal region and inserted into the posterior portions of the basal rims of the coxae. The *Periplaneta* (Fig. 6, 24, 25) and *Locusta* (Fig 8, 25, 26) have two posterior spinal remotors, and the *Atractomorpha* (Fig. 9, 23) and *Brachytrupes* (Fig. 11, 22) have a posterior spinal remotor, on each coxa; but the *Hierodula, Megacrania* and *Xiphidion* lack the muscles. The ordinary sternal remotors are muscles connecting the sternal plates or the bases of the furcal arms with the posterior basal rims of the coxae. The *Hierodula* (Fig. 7, 29), *Megacrania, Xiphidion* (Fig. 10, 21), and *Brachytrupes* (Fig. 11, 23) have an ordinary sternal remotor on each coxa, but in the *Periplaneta, Locusta* and *Atractomorpha* lacking.

(*f*) *Pleural Adductors*

The pleural adductors are found on Phasmidae (JEZIORSKI, 1918, MAKI, 1935) and Gryllotalpidae (CARPENTIER, 1923, 1936), but lacking in many others.

(*g*) *Sternal Adductors*

The sternal adductors are muscles connecting the sternal plates or the furcal arms with the median basal rims of the coxae. The *Periplaneta* (Fig. 6, 26), *Hierodula* (Fig. 7, 30), *Megacrania, Locusta* (Fig. 8, 27), *Atractomorpha* (Fig. 9, 24), *Xiphidion* (Fig. 10, 22) and *Brachytrupes* (Fig. 11, 24) have a sternal adductor on each coxa, and the muscle in the third species arises on the sternal plate and in the others on the furcal arms.

(*h*) *Tergal Abductors*

The tergal abductors are muscles originated on the tergum and attached on the antero-lateral basal rim of the coxa. The *Perip-*

laneta (Fig. 6, 27, 28) has two tergal abductors on each coxa, the first arises on the anterior portion of the median region of the tergum, the second on the anterior portion of the dorso-lateral region of the tergum outside the first anterior internal tergo-sternal muscle (Fig. 6, 11). The *Hierodula* (Fig. 7, 31) and *Megacrania* have a tergal abductor on each coxa, the muscle of the former species is very thick, arising on the anterior portion of the dorso-lateral region of the tergum, of the latter species on the anterior portion of the median ridge of the tergum. The *Locusta, Atractomorpha, Xiphidion* and *Brachytrupes* lack the tergal abductors.

(*i*) *Pleural Abductors*

The pleural abductors are bundles of fibers arising on the pleuron and inserted into the antero-lateral basal rim of the coxa by a tendon. The arising positions of the muscles on the pleuron vary in different species. The *Hierodula* (Fig. 7, 32) and *Megacrania* have a very thick and fan-shaped pleural abductor on each coxa, the muscle of the former arises on the dorsal pleural invagination attached on the tergal wall, the muscle of the latter on the episternum along the pleural ridge. The *Periplaneta* (Fig. 6, 29, 30), *Locusta* (Fig.8, 28, 29), *Atractomorpha* (Fig. 9, 25, 26), *Xiphidion* (Fig. 10, 23, 24) and *Brachytrupes* (Fig. 11, 25, 26) have two pleural abductors on each coxa; the muscles of the *Periplaneta* and *Locusta* are thick, arising on the anterior portion of the episternum; in the *Atractomorpha*, the first muscle arises on the episternum along the pleural ridge, the second on the upper portion of the episternal region of the pleural invagination attached to the tergal wall; in the *Xiphidion*, the first muscle arises on the anterior portion of the episternum, the second on the upper portion of the episternal region of the pleural invagination attached to the tergal wall; in the *Brachytrupes*, the first muscle takes its origin on the anterior portion of the episternum, the second on the upper portion of the very long dorsal invagination of the pleuron attached to the tergal wall.

8) Trochanteral Muscles Arising on the Thorax

(a) Tergal Depressors

The tergal depressors are strong muscles arising on the tergum, running downwards behind the furco-entopleural muscles, and inserted into the common depressor apodeme of the ventral base of the trochanter. The *Periplaneta* (Fig. 6, **31**), *Locusta* (Fig. 8, **30**), *Atractomorpha* (Fig. 9, **27**), *Xiphidion* (Fig. 10, **25**) and *Brachytrupes* (Fig. 11, **27**) have a tergal depressor, the *Hierodula* (Fig. 7, **33, 34, 35**) has three tergal depressors, on each trochanter; but the *Megacrania* lacks the muscles. The tergal depressor of the *Periplaneta* takes its origin on the middle of the lateral region of the tergum, in the *Locusta*, *Atractomorpha* and *Xiphidion* on the middle portion of the dorso-lateral region of the tergum, in the *Brachytrupes* on the anterior portion of the dorso-lateral region of the tergum; in the *Hierodula*, the first muscle arises on the dorso-lateral region of the tergum behind the transverse ridge of the tergum and between the second tergo-pleural muscle (Fig. 7, **15**) and the second tergal promotor of the coxa (Fig. 7, **18**), the second tergal depressor on the more posterior position of the dorso-lateral region of the tergum behind the first tergo-pleural muscle (Fig. 7, **14**), and the third tergal depressor on the lateral region of the tergum immediately behind the transverse tergal ridge.

(b) Pleural Depressors

The pleural depressors are muscles arising on the pleuron and inserted into the common depressor apodeme of the ventral base of the trochanter. The muscles are one-bundled in the *Periplaneta* (Fig. 6, **32**), *Hierodula* (Fig. 7, **36**), *Megacrania*, *Atractomorpha* (Fig. 9, **28**), two-bundled in the *Locusta* (Fig. 8, **31, 32**), *Xiphidion* (Fig. 10, **26, 27**), and three-bundled in the *Brachytrupes* (Fig. 11, **28, 29, 30**). The muscle in the *Periplaneta*, *Hierodula* and *Megacrania* arises on the pleural ridge or the episternum along the pleural ridge, the muscle of the *Atractomorpha* on the anterior dorsal portion in the episternal region of the dorsal pleural invagination attached to the tergal wall; in the *Locusta*, the first muscle arises on the antero-dorsal portion of

the episternum, the second on the pleural ridge; in the *Xiphidion*, the first muscle originates on the dorsal portion of the episternal region of the pleural invagination attached to the tergal wall, the second arises on the epimeral region behind the first muscle and runs downwards behind the furco-entopleural muscle (Fig. 10, **14**); in the *Brachytrupes*, the first muscle rises on the dorsal porion of the long dorsal pleural invagination attached to the tergal wall, the second and the third take their origins on the same pleural invagination more posteriorly than the first, and the former runs downwards before the furco-entopleural muscle (Fig. 11, **15**) as the first pleural depressor, while the latter passes the posterior side of the furco-entopleural muscle.

(*c*) *Sternal Depressors*

The sternal depressors are muscles arising on the furcal arms and inserted into the commen depressor apodemes of the trochanters. The *Atractomorpha* (Fig. 9, **29**), *Xiphidion* (Fig. 10, **28**) and *Brachytrupes* (Fig. 11, **31**) have a sternal depressor on each trochanter. The *Periplaneta*, *Hierodula*, *Megacrania* and *Locusta* lack the sternal depressors of the trochanters.

b. Mesothoracic Musculature

1) Dorsal Muscles

The dorsal muscles may be divided into two kinds, median and lateral.

The *Periplaneta*, *Hierodula*, *Megacrania*, and *Locusta*, *Xiphidion* and *Brachytrupes* have both the median and the lateral dorsal muscles, but the *Atractomorpha* lacks the latter. The median dorsal muscles in the *Periplaneta* (Fig. 6, **33**, **34**), *Megacrania*, *Locusta* (Fig. 8, **33**, **34**) and *Atractomorpha* (Fig. 9, **30**, **31**) are of two pairs, the first or internal and the second or external; the internal median dorsal muscle is longer than the external and, although the muscle in the *Megacrania* arises on the posterior portion of the tergum exceptionaly, originated on the phragma of the anterior end of the tergum and inserted into the phragma on the anterior end of the metatergum; the external median dorsal muscle is short, arising anteriorly

on the middle of the median region of the scutum along the ridge between the scutum and the scutellum as in the *Periplaneta* or on the posterior portion of the scutum outside the scutellum as in the *Megacrania*, *Locusta* and *Atractomorpha*, and inserted posteriorly into the phragma on the anterior end of the metatergum. The *Hierodula* (Fig. 7, **37**), *Xiphidion* (Fig. 10, **29**) and *Brachytrupes* (Fig. 11, **32**) have a median dorsal muscle on each side, the muscle of the first species is short, originating in the posterior portion of the scutum outside the scutellum and the metatergum, but the muscle in the second and third species is long and stretched between the phragmata of the anterior ends of the meso- and metatergum.

The lateral dorsal muscles of the *Periplaneta* (Fig. 6, **35, 36**), *Hierodula* (Fig. 7, **38, 39**), *Megacrania*, *Locusta* (Fig. 8, **35, 36**) are two-paired, internal and external; both the internal and the external dorsal muscles in the *Periplaneta* arise on the middle of the median region of the tergum along the ridge between the scutum and the scutellum and are inserted into the lateral portion of the anterior end of the metatergum; in the *Hierodula*, the internal lateral dorsal muscle arises on the middle of the median region of the scutum along the ridge between the scutum and scutellum, the external lateral dorsal muscle on the more lateral position of the scutum, and both are inserted into the lateral portion of the anterior end of the metatergum; in the *Megacrania* and *Locusta*, both the internal and the external lateral muscle take their origins on the postero-lateral region of the scutum and their insertions into the lateral portion of the anterior end of the metatergum. The *Xiphidion* (Fig. 10, **30**) and *Brachytrupes* (Fig. 11, **33**) have one pair of lateral dorsal muscles, each muscle arises on the middle of the median region of the tergum and attaches on the lateral portion of the anterior end of the metatergum.

2) Dorsal Transverse Muscles

The mesothoracic dorsal transverse muscles are found in one pair on the *Periplaneta* (Fig. 6, **37**), but lacking on the others. The muscles arise on the lateral portions of the anterior end of the tergum, and are attached on the ventral side of the dorsal vessel after diverging.

3) Ventral Muscles

There are six kinds of ventral muscles, longitudinal ventrals, unpaired longitudinal median ventrals, oblique profurco-metaspinal ventrals, oblique mesospino-mesofurcal ventrals, anterior ventrals and posterior ventrals.

The longitudinal ventral muscles are one-paired in the *Periplaneta* (Fig. 6, **38**), *Hierodula* (Fig. 7, **40**), *Locusta* (Fig. 8, **37**), *Atractomorpha* (Fig. 9, **32**), *Xiphidion* (Fig. 10, **31**) and *Brachytrupes* (Fig. 11, **34**), but lack in the *Megacrania*. They are thick, attached anteriorly on the profurcal arms or the posterior ends of the prosterna (as in the *Hierodula*) and posteriorly on the mesofurcal arms.

The unpaired median ventral muscle is slender, attached anteriorly on the spina (mesospina) at the median posterior end of the prosternum, and posteriorly to the spina (metaspina) at the median posterior end of the mesosternum. The muscle is found on the *Periplaneta* (Fig. 6, **39**), *Hierodula* (Fig. 7, **41**), *Locusta* (Fig. 8, **39**), *Xiphidion* (Fig. 10, **32**) and *Brachytrupes* (Fig. 11, **35**), but lacks in the *Megacrania* and *Atractomorpha*.

The oblique profurco-metaspinal ventral muscles are bundles of fibers arising on the profurcal arms and inserted into the spina (metaspina) on the median posterior end of the mesosternum. The muscles are found in one pair on the *Brachytrupes* (Fig. 11, **36**), but are lacking in the others. According to MIALL and DENNY (1886), in *Periplaneta orientalis* there are muscles running from the metaspina forwards and outwards to the fore leg bases ; they may be probably homologous to the oblique profurco-metaspinal ventral muscles, though their anterior attached portions are doubtful.

The oblique mesospino-mesofurcal ventrals are slender muscles attached anteriorly on the spina (mesospina) at the median posterior end of the prosternum and posteriorly on the mesofurcal arms. The *Hierodula* (Fig. 7, **42**), *Locusta* (Fig. 8, **39**), *Atractomorpha* (Fig. 9, **33**), *Xiphidion* (Fig. 10, **33**) and *Brachytrupes* (Fig. 11, **37**) have an oblique mesospino-mesofurcal ventral muscle on each side, but the *Periplaneta* and *Megacrania* lacking.

The anterior ventral muscles are found in one pair on the anterior subdivision of the mesosternum of the *Megacrania*.

The posterior ventral muscles are found in one pair only on the *Hierodula* (Fig. 7, **43**), they are very slender muscles arising on the mesofurcal arms and inserted into the antero-lateral corners of the metasternum.

4) Ventral Transverse Muscles

The ventral transverse muscles are divided into two, anterior and posterior. The anterior ventral transverse muscle is found on each side in the *Periplaneta* (Fig. 6, **40**), *Hierodula* (Fig. 7, **44**) and *Xiphidion* (Fig. 10, **34**), but lack in the *Megacrania*, *Locusta*, *Atractomorpha* and *Brachytrupes*. It is very slender, takes its lateral origin on the intersegmental membrane near the antero-lateral corner of the mesosternum (as in the *Hierodula*) or the anterior side of the mesepisternum (on the small sclerite before the episternum as in the *Periplaneta*, or on the antero-ventral corner of the episternum as in the *Xiphidion*) and its median attachment on the spina (mesospina) of the posterior end of the prosternum.

The posterior ventral transverse muscle is found on the *Periplaneta* (Fig. 6, **41**), *Megacrania* and *Xiphidion* (Fig. 10, **35**); the muscle in the *Periplaneta* and *Xiphidion* arises on the furcal arm and is inserted into the spina on the posterior end of the sternum, the muscle in the *Megacrania* is stretched between the furcal arms of both sides directly.

5) Tergo-Sternal Muscles

In the tergo-sternal muscles are found two kinds, anterior and posterior. The Anterior tergo-sternal muscles are one-paired in the *Periplaneta* (Fig. 6, **42**), *Hierodula* (Fig. 7, **45**), *Megacrania*, *Xiphidion* (Fig. 10, **36**) and *Brachytrupes* (Fig. 11, **38**), and three-paired in the *Locusta* (Fig. 8, **40, 41, 42**) and *Atractomorpha* (Fig. 9, **34, 35, 36**). The anterior tergo-sternal muscles arise on the antero-lateral regions of the tergum, and are inserted into the lateral portions of the so-called basisternum in the *Periplaneta*, *Hierodula* and *Xiphidion*, into the sterno-pleural bridges before the coxae in the *Locusta*, *Atracto-*

morpha and *Brachytrupes*, and into the lateral portion of the presternum in the *Megacrania*.

The posterior tergo-sternal muscles are one-paired in the *Periplaneta* (Fig. 6, **43**), *Megacrania*, *Locusta* (Fig. 8, **43**), and *Brachytrupes* (Fig, 11, **39**), and two-paired in the *Hierodula* (Fig. 7, **46**, **47**), but lack in the *Atractomorpha* and *Xiphidion*. These muscles arise dorsally on the antero-lateral corners of the metatergum, exceptionally the second pair of the *Hierodula* (**47**) on the peritremes of the second thoracic spiracles, and attach ventrally on the mesofurcal arms.

6) Tergo-Pleural Muscles

The tergo-pleural muscles are divisible into three kinds, ordinary tergo-pleurals, pleuro-axillary muscles, and pleuro-subalar muscles.

The ordinary tergo-pleural muscles are bundles of fibers arising on the tergal plate and inserted into the pleuron. The *Periplaneta* (Fig. 6, **44**, **45**, **46**, **47**) has four muscles on each side, the first (**44**) arises on the anterior end of the tergum at the outside of the medion internal dorsal muscle, the second (**45**) on the more postero-lateral position of the tergum, and both are inserted into the anterior margin of the pleuron, the third (**46**) arises on the lateral portion of the tergum between the anterior and the posterior notal wing process and is inserted into the upper side of the pleural arm, the fourth (**47**) attaches dorsally on the lateral portion of the tergum behind the third muscle and ventrally on the pleural ridge. The *Hierodula* (Fig. 7, **48**, **49**, **50**) has three on each side, the first (**48**) is strong, and attaches dorsally on the antero-lateral portion of the tergum and ventrally on the anterior margin of the anterior basalare, the second (**49**) and the third (**50**) are very similar to the third (**46**) and the fourth (**47**) of the *Periplaneta* respectively. In the *Megacrania* are found two on each side, the first is very broad and stretched between the lateral portion of the tergum and the dorsal margin of the episternum, and the second is slender and connects the lateral portion of the tergum at the inside of the wing with the pleural ridge. In the *Locusta* (Fig, 8, **44**, **45**, **46**) are observed three on each side, the first (**44**) connects the latero-anterior portion of the tergum with the anterior margin of

the pleuron, the second (**45**) connects the latero-anterior portion of the tergum with the dorsal portion of the pleural ridge, the third (**46**) attached dorsally on the lateral portion of the tergum between the anterior notal wing process and the fourth axillary, and ventrally on the middle portion of the pleural ridge. The *Xiphidion* (Fig. 10, **37**, **38**) has two on each side, the first (**37**) is very similar to the second muscle in the *Locusta* (Fig. 8, **45**), and the second is similar to the third muscle of the *Periplaneta* (Fig. 6, **46**). The *Brachytrupes* (Fig. 11, **40**) has only an ordinary tergo-pleural muscle very similar to the first one in the *Xiphidion* (Fig. 10, **37**). The *Atractomorpha* lacks the ordinary tergo-pleural muscle.

The pleuro-axillary muscles are found in one pair on the *Periplaneta* (Fig. 6, **48**), *Hierodula* (Fig, 7, **51**), *Locusta* (Fig. 8, **47**), *Xiphidion* (Fig. 10, **39**), and *Brachytrupes* (Fig. 11, **41**), and in two pairs on the *Megacrania* and *Atractomorpha* (Fig. 9, **37**, **38**). These muscles, except the second of the *Megacrania* which arises on the pleural ridge and is inserted into the fourth axillary, are attached dorsally on the third axillary sclerites and ventrally on the dorsal portions of the episterna (as in the muscle of the *Periplaneta* and the first muscle of the *Megacrania*) or the pleural ridge (as in the muscles of the remains).

The pleuro-subalar muscle is a small bundle of fibers arising on the upper portion of the epimeron and inserted into the subalare. It is found in one pair on the *Megacrania* (the muscle described as a pleural muscle (**106**) by the writer, 1935, Fig. 22) and *Locusta* (Fig. 8, **48**), but lacks in the others.

7) Sterno-Pleural Muscles

The sterno-pleural muscles may be divided into three kinds, ordinary sterno-pleural muscles, sterno-basalar muscles, and furco-ento-pleural muscles. The ordinary sterno-pleural muscles are found in three pairs on the *Megacrania*, but lack in the other species. The sterno-basalar muscle is a bundle of fibers arising on the lateral portion of the ventral region of the segment and inserted into the basalare. It is found on the *Megacrania*, *Locusta* (Fig. 8, **49**), *Atracto-*

morpha (Fig. 9, **39**) and *Brachytrupes* (Fig. 11, **42**). The furco-ento-pleural muscles connect the furcal arms with the pleural arms, and are found in one pair on all the species. (Fig. 6, **49**; Fig. 7, **52**; Fig. 8, **50**; Figs. 9, 10, **40**; Fig. 11, **43**).

8) Coxal Muscles, Coxal and Trochantinal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors are found in one pair on the *Periplaneta* (Fig. 8, **50**), *Megacrania*, *Locusta* (Fig. 8, **51**), *Atractomorpha* (Fig. 9, **41**), *Xiphidion* (Fig. 10, **41**) and *Brachytrupes* (Fig. 11, **44**), and in two pairs on the *Hierodula* (Fig. 7, **53, 54**). The tergal promotor is strong, fan-shaped, attached ventrally on the trochantin and dorsally on the antèrior portion of the tergum in general, although the muscle of the *Megacrania* attaches on the posterior portion of the tergum.

(*b*) *Pleural Promotors of the Coxae, and Trochantino-Basalar Muscles*

The muscles stretched between the episternal region and the trochantin are divisible into two kinds, pleural promotors of the coxa arising on the main episternal region and attached on the trochantin, and trochantino-basalar muscles stretched between the trochantin and the basalar sclerite detached from the episternal region. The pleural promotor of the coxa is found on each side of the *Hierodula* (Eig. 7, **55**). The trochantino-basalar muscle is found on each side of the *Periplaneta* (Fig. 6, **51**), *Hierodula* (Fig. 7, **56**), *Xiphidion* (Fig. 10, **42**) and *Brachytrupes* (Fig. 11, **45**). The *Megacrania*, *Locusta* and *Atractomorpha* lack both muscles.

(*c*) *Sternal Promotors of the Coxae*

The sternal promotors may be divided into two kinds, anterior spinal promotors and ordinary sternal promotors. The anterior spinal promotor is a muscle arising on the spina (mesospina) on the posterior end of the prosternum and inserted into the anterior coxal margin. The *Xiphidion* (Fig. 10, **43**) and *Brachytrupes* (Fig. 11, **46**) have an anterior spinal promotor of the coxa on each side, but the others lack it. The ordinary sternal promotor is a muscle attached on the furcal arm or the sternal plate near the furcal arm, and on the anterior margin of the coxa or rarely on the apex of the trochantin as in the

Megacrania. The *Periplaneta* (Fig. 6, 52), *Hierodula* (Fig. 7, 57), *Locusta* (Fig. 8, 52), *Atractomorpha* (Fig. 9, 42), *Xiphidion* (Fig. 10, 44), *Brachytrupes* (Fig. 11, 47) have an ordinary sternal promotor, and the *Megacrania* has two ordinary sternal promotors, on each side.

(*d*) *Tergal Remotors of the Coxae and Coxo-Subalar Muscles*

The muscles stretched between the tergal regions and the posterior basal margins of the coxae include tergal remotors of the coxae and coxo-subalar muscles. The tergal remotors are strong, arising on the terga, inserted into the posterior basal rims of the coxae, and often divided into internals and externals. The internal tergal remotors are very thick, and take their origins on the terga more forward and inward than in the externals. The arising positions of the internal tergal remotors vary in different species: Those in the *Periplaneta* (Fig. 6, 53), *Atractomorpha* (Fig. 9, 43) and *Brachytrupes* (Fig. 11, 48) on the anterior median portions of the terga, in the *Hierodula* (Fig. 7, 58), *Xiphidion* (Fig. 10, 45) and *Locusta* (Fig. 8, 53) on the about middle portions of the median regions of the terga, and in the *Megacrania* on the postero-lateral regions of the terga. The external tergal remotors are one-bundled on each coxa in the *Periplaneta* (Fig. 6, 54), *Megacrania*, *Locusta* (Fig. 8, 54), *Atractomorpha* (Fig. 9, 44), *Xiphidion* (Fig. 10, 46) and *Brachytrupes* (Fig. 11, 49), and two-bundled on each coxa of the *Hierodula* (Fig. 7, 59, 60). The external tergal remotors in the *Periplaneta* take their origins on the anterior portions of the dorso-lateral regions of the terga along the tergal transverse ridges, in the other species arise on the lateral tergal regions posterior to the anterior notal wing processes.

The coxo-subalar muscles are very thick, attached dorsally on the subalar plates and ventrally on the postero-lateral portions of the coxae. All the species have a coxo-subalar muscle on each coxa (Fig. 6, 55; Fig. 7, 61; Fig. 8, 55; Fig. 9, 45; Fig. 10, 47; Fig. 11, 50).

(*e*) *Sternal Remotors of the Coxae*

The sternal remotors divide into posterior spinal remotors and ordinary sternal remotors, the former arise on the spinae (metaspinae) of the posterior median ends of the sterna, and the latter on the fur-

cal arms or the sternal walls near the furcal arms, both attached on the posterior basal margins of the coxae. The *Periplaneta* (Fig. 6, **56**) has only a posterior spinal remotor, the *Locusta* has only an ordinary sternal remotor (Fig. 8, **56**), the *Megacrania* has two ordinary sternal remotors, and the *Hierodula* (Fig. 7, **62, 63**), *Atractomorpha* (Fig. 9, **46, 47**), *Xiphidion* (Fig. 10, **48, 49**), and *Brachytrupes* (Fig. 11, **51, 52**) have a posterior spinal remotor and an ordinary sternal remotor, on each coxa.

(*f*) *Pleural Adductors of the Coxae*

The pleural adductor are one-paired in the *Megacrania*, but lacking in the others.

(*g*) *Sternal Adductors of the Coxae*

Each coxa in the species (Fig. 6, **57**; Fig. 7, **64**; Fig. 8, **57**; Fig. 9, **48**; Fig. 10, **50**; Fig. 11, **53**) except in the *Megacrania*, has a sternal adductor arising on the base of the furcal arm and inserted into the median portion of the basal margin of the coxa.

(*h*) *Tergal Abductors of the Coxae*

The *Locusta* (Fig. 8, **58**) has a tergal abductor arising on the lateral portion of the tergum anterior to the wing base and inserted into the antero-lateral portion of the basal coxal rim on each side, but the other species lack it.

(*i*) *Pleural Abductors of the Coxae and Coxo-Basalar Muscles*

The muscle stretched between the antero-lateral portions of the coxal bases and the pleura are divisible into two kinds, pleural abductors of the coxae and the coxo-basalar muscles. The pleural abductors are fan-shaped, arising in the episterna and inserted into the antero-lateral basal rims of the coxae. The *Megacrania* has three pleural abductors, and the *Periplaneta* (Fig. 6, **58, 59**), *Hierodula* (Fig. 7, **65, 66**), *Locusta* (Fig. 8, **59, 60**), *Atractomorpha* (Fig. 9, **49, 50**), *Xiphidion* (Fig. 10, **51, 52**) and *Brachytrupes* (Fig. 11, **54, 55**) have two pleural abductors, on each coxa.

The coxo-basalar muscles are bundles of fibers attached dorsally on the basalar sclerites and ventrally on the antero-lateral portions of the coxal bases. The *Hierodula* (Fig. 7, **67, 68**) and *Megacrania*

have two coxo-basalar muscles, and the *Periplaneta* (Fig. 6, **60**), *Locusta* (Fig. 8, **61**), *Atractomorpha* (Fig. 9, **51**), *Xiphidion* (Fig. 10, **53**) and *Brachytrupes* (Fig. 11, **56**) have a coxo-basalar muscle, on each side.

9) Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles

(a) Tergal Depressors of the Trochanters

The *Periplaneta* (Fig. 6, **61**), *Hierodula* (Fig. 7, **69**), *Megacrania*, *Locusta* (Fig. 8, **62**), *Xiphidion* (Fig. 10, **54**) and *Brachytrupes* (Fig. 11, **57**) have a tergal depressor, and the *Atractomorpha* (Fig. 9, **52**, **53**) has two tergal depressors, on each trochanter. The tergal depressors are very thick, arising on the anterior portions of the dorso-lateral regions of the terga (as in the *Periplaneta*, *Hierodula*, *Atractomorpha*, *Brachytrupes*), the about middle portions of the dorso-lateral regions of the terga (as in the *Locusta* and *Xiphidion*) or the more posterior portions of the terga (still at the anterior sides of the wing bases, as in the *Megacrania*), and inserted into the common depressor apodemes on the ventral bases of the trochanters. The tergal depressors in the mesothorax usually run downwards before the furco-entopleural muscles.

(b) Trochantero-Basalar Muscles

The muscles stretched between the basalar sclerites and the common depressor apodemes of the trochanters are two-paired in the *Periplaneta* (Fig. 6, **62**, **63**), one-paired in the *Hierodula* (Fig. 7, **70**), *Megacrania*, *Xiphidion* (Fig. 10, **55**) and *Brachytrupes* (Fig. 11, **58**).

(c) Sternal Depressors of the Trochanters

The sternal depressors arise on tne furcal arms and are inserted into the common depressor apodemes on the ventral bases of the trochanters. The species except the *Megacrania* (Fig. 6, **64**; Fig. 7, **71**; Fig. 8, **63**; Fig. 9, **54**; Fig. 10, **56**; Fig. 11, **59**) have one pair of the sternal depressors.

10) Muscles of the First Thoracic Spiracles

The *Periplaneta* (Fig. 6, **65**) and *Xiphidion* (Fig. 10, **57**) have an occlusor on each first thoracic spiracle, the muscle of the former

species on the ventral end of the subspiraculare, and of the latter species originates on the anterior margin of the mesepisternum, both inserted into the ventral ends of the spiracles.

The *Hierodula* (Fig. 7, **72, 73**) and *Megacrania* have two occlusors on each first thoracic spiracle: In the first species, the firgt occlusor (**72**) is attached dorsally on a small rod of the septum between the openings of two main tracheae, and the second occlusor (**73**) on the anterior lip of the spiracle, both are cruciate to each other and originated on the subspiraculare. In the second species, the two occlusors arise on the subspiraculare and are inserted into the ventral side of the spiracle.

The first thoracic spiracle in the *Locusta* (Fig. 8, **64, 65**), *Atractomorpha* (Fig. 9, **55, 56**) and *Brachytrupes* (Fig. 11, **60, 61**) have two muscles on each first thoracic spiracle, one is an occlusor (Fig. 8, **64**; Fig. 9, **55**; Fig. 11, **60**) very similar to the first occlusor in the *Hierodula* (Fig. 7, **72**), the other is a dilator (Fig. 8, **65**; Fig. 9, **56**; Fig. 11, **61**) arising on the subspiraculare and attached on the posterior lip of the spiracle.

c. Metathoracic Musculature

1) Dorsal Muscles

The *Periplaneta* (Fig. 6, **66, 67, 68, 69**) and *Megacrania* have four dorsal muscles on each side, a median internal, a median external, a lateral internal, and a lateral external dorsal muscle, similar to those of their mesothorax respectively, but the lateral dorsal muscle of the first species is shorter than that of its mesothorax, and also the median and lateral internal dorsal muscles of the second species are longer than those of its mesothorax. The *Hierodula* (Fig. 7, **74, 75**) has a median dorsal and a lateral dorsal muscle similar to those of its mesothorax (Fig. 7, **37, 39**) on each side. The *Locusta* (Fig. 8, **66**), *Xiphidion* (Fig. 10, **58**), *Brachytrupes* (Fig. 11, **62**) have a median dorsal muscle similar to that of their mesothorax (Fig. 8, **33**; Fig. 10, **29**; Fig. 11, **32**) on each side. The *Atractomorpha* (Fig. 9, **57, 58**) has a median internal dorsal muscle similar to that in its mesothorax

(Fig. 9, **30**), and a median external dorsal muscle longer than that in its mesothorax (Fig. 9, **31**) on each side.

2) **Dorsal Transverse Muscles**

The *Periplaneta* (Fig. 6, **70**) and *Hierodula* (Fig. 7, **76**) have a dorsal transverse muscle similar to the mesothoracic dorsal transverse muscle of the former species (Fig. 6, **37**), on each antero-lateral portion of the terga, but the others lack it.

3) **Ventral Muscles**

The *Periplaneta* has a pair of longitudinal ventral muscles (Fig. 6, **71**) and an unpaired median ventral muscle (Fig. 6, **72**) corresponding to the mesothoracic ventral muscles (Fig. 6, **38, 39**) respectively, and a pair of oblique spino-furcal ventral muscles (Fig. 6, **73**) similar to the mesothoracic ones of the *Locusta*. The *Megacrania* has an internal and an external longitudinal ventral muscles arising on the anterior portion of the sternum and attached on the furcal arm on each side. The *Hierodula* (Fig. 7, **77, 78**), *Locusta* (Fig. 8, **67, 68**), *Xiphidion* (Fig. 10, **59, 60**) and *Brachytrupes* (Fig. 11, **63, 64**) have a pair of longitudinal ventrals and a pair of oblique spino-furcal ventrals corresponding to those of their mesothorax (Fig. 7, **40, 42**; Fig. 8, **37, 39**; Fig. 10, **31, 33**; Fig. 11, **34, 37**) respectively. The *Atractomorpha* has no ventral muscle in the metathorax.

4) **Ventral Transverse Muscles**

The *Periplaneta* and *Xiphidion* have an anterior ventral transverse muscle (Fig. 6, **74**; Fig. 10, **61**) very similar to that of the mesothorax (Fig. 6, **40**; Fig. 10, **34**) on each side, but lack the muscle corresponding to the posterior ventral transverse muscle of the mesothorax (Fig. 6, **41**; Fig. 10, **35**). The *Hierodula* has no ventral transverse muscle. The *Megacrania* has a posterior ventral transverse muscle very similar to that of the mesothorax. The *Locusta* has an anterior ventral transverse muscle (Fig. 8, **69**) resembling the muscle of the *Periplaneta* (Fig. 6, **40** or **74**), and a posterior ventral transverse muscle stretched between the furcal arms of both sides directly (Fig. 8, **70**). The *Atractomorpha* has a posterior ventral transverse muscle (Fig, 9, **59**) very similar to that of the *Locusta* (Fig. 8, **70**). In the

Brachytrupes there is an anterior ventral transverse muscle (Fig. 11, **65**), similar to that in the *Xiphidion*, on each side.

5) **Tergo-Sternal Muscles**

The *Periplaneta* (Fig. 6, **75**), *Hierodula* (Fig. 7, **79**) and *Brachytrupes* (Fig. 11, **66**) have only a pair of posterior tergo-sternal muscles similar to their mesothoracic ones (Fig. 6, **43**; Fig. 7, **46**; Fig. 11, **39**). The *Megacrania*, *Locusta* (Fig. 8, **71, 72**) and *Atractomorpha* (Fig. 9, **60 ,61**) have an anterior tergo-sternal muscle and a posterior tergo-sternal muscle on each side; those in the first species are similar to those in its mesothorax, those in the second and third species resemble those of the mesothorax of the first species in their attached positions. The *Xiphidion* has no tergo-sternal muscle.

6) **Tergo-Pleural Muscles**

The metathorax of the *Periplaneta* (Fig. 6, **76, 77, 78, 79**, **80**), *Hierodula* (Fig. 7, **80, 81, 82, 83**) and *Atractomorpha* (Fig. 9, **62, 63**) has tergo-pleural muscles very similar to those of their mesothorax (Fig. 6, **44, 45, 46, 47, 48**; Fig. 7, **48, 49, 50, 51**; Fig. 9, **37, 38**), respectively. The *Megacrania* has three pairs of tergo-pleural muscles arising on the tergum and inserted into the basalar sclerites, but lacking the broad ordinary tergo-pleural musctes found on the mesothorax. The *Locusta* has four tergo-pleural muscles (Fig. 8, **73, 74, 75, 76**) similar to the mesothoracics (Fig. 8, **44, 45, 46, 47**) respectively on each side, but lacks the muscle corresponding to the mesothoracic pleuro-subalar muscle (Fig. 8, **48**). The *Xiphidion* has two tergo-pleural muscles (Fig. 10, **62, 63**) corresponding to the first ordinary tergo-pleural and the pleuro-axillary muscle (Fig. 10, **37, 39**) of the mesothorax respectively, and a pleuro-subalar muscle (Fig. 10, **64**) similar to the mesothoracic pleuro-subalar muscle of the *Locusta* (Fig. 8, **48**), on each side, but lacks the muscle corresponding to the second ordinary tergo-pleural muscle (Fig. 10, **38**) of the mesothorax. The *Brachytrupes* has an ordinary tergo-pleural muscle and a pleuro-axillary muscle (Fig. 11, **76** & **68**) similar to those in the mesothorax (Fig. 11, **40, 41**), and a pleuro-subalar muscle (Fig. 11, **69**) similar to that in the *Xiphidion* (Fig. 10, **64**), on each side.

7) Sterno-Pleural Muscles

On each side in the *Periplaneta*, *Hierodula*, *Xiphidion* and *Brachytrupes* there is a furco-entopleural muscle (Fig. 6, **81**; Fig. 7, **84**; Fig. 10, **65**; Fig. 11, **70**) similar to their mesothoracic one (Fig. 6, **49**; Fig. 7, **52**; Fig. 10, **40**; Fig. 11, **43**). The *Megacrania* has a pair of broad ordinary sterno-pleural muscles, three pairs of sterno-basalar muscles, and a pair of furco-entopleural muscles. The *Locusta* and *Atractomorpha* have two-paired sterno-basalar muscles (Fig. 8, **77, 78**; Fig. 9, **64, 65**) and one-paired furco-entopleural muscles (Fig. 8, **79**; Fig. 9, **66**) similar to those in their mesothorax (Fig. 8, **49**; Fig. 9, **39**; Fig. 8, **50**; Fig. 9, **40**) in their attached positions respectively, though the mesothoracic sterno-basalar muscles are one-paired.

8) Coxal Muscles, Coxal and Trochantinal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors of the coxae are similar to those of the mesothoracic coxae, except that those of the *Brachytrupes* are two-bundled, of the *Locusta* attach dorsally on the more anterior positions of the terga, and of the *Megacrania* take their origins on the middle portions of the lateral regions of the terga. (Fig, 6, **82**; Fig. 7, **85, 86**; Fig. 8, **80**; Fig. 9, **67**; Fig. 10, **66**; Fig. 11, **71, 72**).

(*b*) *Pleural Promotors of the Coxae and Trochantino-Basalar Muscles*

The *Hierodula* (Fig. 7, **87**) has a pair of pleural promotors of the coxae, and these are similar to those of the mesothorax (Fig. 7, **55**). The *Periplaneta*, *Hierodula*, *Xiphidion* and *Brachytrupes* have a pair of trochantino-basalar muscles (Fig. 6, **83**; Fig. 7, **88**; Fig. 10, **67**; Fig. 11, **73**) very similar to those of their mesothorax (Fig. 6, **51**; Fig. 7, **56**; Fig. 10, **42**; Fig. 11, **45**) respectively. The *Megacrania*, *Locusta* and *Atractomorpha* lack both kinds of muscles.

(*c*) *Sternal Promotors of the Coxae*

The *Periplaneta*, *Hierodula*, *Megacrania*, *Xiphidion* and *Brachytrupes* have an ordinary sternal promotor (Fig. 6, **84**; Fig. 7, **89**; Fig. 10, **69**; Fig. 11, **75**) similar to that of their mesothorax (Fig. 6, **52**; Fig. 7, **57**; Fig. 10, **44**; Fig. 11, **47**) on each coxa. The *Locusta* and

Atractomorpha have two ordinary sternal promotors (Fig. 8, **82, 83**; Fig. 9, **68, 69**) similar to those of their mesothorax (Fig. 8, **52**; Fig. 9, **42**) in their attached positions, on each coxa. In the *Locusta, Xiphidion* and *Brachytrupes* there is also an anterior spinal promotor (Fig. 8, **81**; Fig. 10, **68**; Fig. 11, **74**) similar to that of the mesothorax of the second and third species (Fig. 10. **43**; Fig. 11, **46**).

(*d*) *Tergal Remotors of the Coxae and Coxo-Subalar Muscles*

The tergal remotors of the coxae and the coxo-subalar muscles in the seven species are very similar to those of their mesothorax, but the internal tergal remotors in the *Locusta* are two-bundled. The metathoracic muscles correspond to the mesothoracics respectively. In the *Periplaneta* Fig. 6, **85, 86, 87** to **53, 54, 55**; in the *Hierodula* Fig. 7, **90, 91, 92, 93** to **58, 59, 60, 61**; in the *Locusta* Fig. 8, **84** and **85, 86, 87,** to **53, 54, 55**; in the *Atractomorpha* Fig. 9, **70, 71, 72** to **43, 44, 45**; in the *Xiphidion* Fig. 10, **70, 71, 72** to **45, 46, 47**; in the *Brachytrupes* Fig. 11, **76, 77, 78** to **48, 49, 50.**

(*e*) *Sternal Remotors of the Coxae*

The posterior spinal remotors of the coxae lack in the metathorax, but the ordinary sternal remotors are two-paired (Fig. 6, **88, 89**; Fig. 8, **88, 89**; Fig. 9, **73, 74**; Fig. 10, **73, 74**; Fig. 11, **79, 80**) except that those of the *Hierodula* are one-paired (Fig. 7, **94**). Probably the first pair of the ordinary sternal remotors of the metathorax may correspond to the posterior spinal remotors of the mesothorax.

(*f*) *Pleural Adductors of the Coxae*

The pleural adductors are found on only the coxae of the *Megacrania* as in the case of the mesothorax.

(*g*) *Sternal Adductors of the Coxae*

The species, except the *Megacrania,* have sternal adductors on the coxae, these muscles are similar to the mesothoracic ones, but the metathoracic ones of the *Locusta* are two-paired. (Fig. 6, **90**; Fig. 7, **95**; Fig. 8, **90, 91**; Fig. 9, **75**; Fig. 10, **75**; Fig. 11, **81**).

(*h*) *Pleural Abductors of the Coxae and Coxo-Basalar Muscles*

The pleural abductors and coxo-basalar muscles are very similar to those in the mesothorax, except that the pleural abductors in the

TABLE II

Orthoptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figures; "x" shows the displacement of muscles by chitinous bridges; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Blattidae. *Periplaneta australasia.* (Fig. 6)	Mantidae. *Hierodula patellifera* (Fig. 7)	Phasmidae. *Megacrania tsudai* (MAKI, 1935)	Phasmidae. *Dixippus morosus* (JEZIORSKI, 1918)	Acridiidae. *Locusta migratoria manilensis* (Fig. 8)	Acridiidae. *Atractomorpha ambigua* (Fig. 9)	Acridiidae. *Dissosteira carolina* (SNODGRASS, 1929)	Tettigonidae. *Xiphidion maculatum* (Fig. 10)	Gryllidae. *Brachytrupes portentosus* (Fig. 11)	Gryllidae. *Gryllus domesticus* (VOSS, 1905)	Gryllidae. *Gryllus assimilis* (DU PORTE, 1920)
Dorsal Muscles.											
Median dorsals.	2 (1) (2)	2 (1) (2)	1 (65)	1 (Oidlm2)	2 (1) (2)	2 (1) (2)	2 (49) (56)	1 (1)	1 (1)	1 (Odlm 2)	1 (4)
Lateral dorsals.	2 (3) (4)	2 (3) (4)	4 (66) (67) (68) (69)	2 Idlm 3a.) (Idlm 3b.)	2 (3) (4)	2 (3) (4)	1 (58)	2 (2) (3)	1 (2)	1 (Idlm 3)	2 (9) (20)
Anterior dorsals.	1 (5)	2 (5) (6)	2 (70) (71)	3 (Odlm 1) (Fam a+b) (i Fam c+d	2 (5) (6)	1 (5)	2 (47) (48)	2 (4) (5)	1 (3)	2 (Odlm 1) (Idlm 1a)	1 (4)
Ventral Muscles.											
Internal ventrals.	1 (6)	1 (7)	1 (72)	1 (Ivlm 4+5)	1 (7)	1 (6)	1 (55)	1 (6)	1 (4)	2 (Ovlm 4) (Ovlm 5)	2 (1) (2)
External ventrals.	1 (7)	—	1 (73)	1 (Ivlm 3)	2 (8) (9)	2 (7) (8)	—	—	1 (5)	1 (Ovlm 3)	1 (3)
Cruciate ventrals.	—	—	—	—	1 (10)	3 (9) (10)	1 (54)	—	—	—	—
Anterior ventrals.	—	—	—	—	1 (11)		—	1 (7)	1 (6)	—	1 (11)
Ventral Transverse Muscles.	1 (8)	—	—	—	1 (12)	—	1 (61)	1 (8)	1 (7)	1 (Ivlm 3)	1 (18)
Tergo-Sternal Muscles.											
Anterior intersegmental tergo-sternals.	2 (9) (10)	1 (8)	2 (76) (77)	2 Odvm 2b) (Odvm 2c)	2 (13) (14)	2 (11) (12)	2 (50) (51)	2 (9) (10)	1 (8)	4 (Odom β, γ, δ) (Oidvm 2)	2 (9) (10)
Anterior internal tergo-sternals.	3 (11) (12) (13)	3 (9) (10) (11)	2 (60) (61)	2 (Oism 2) (Odvm 2a)	2 (15) (16)	2 (13) (14)	3 (52a) (52b) (53)	2 (11) (12)	2 (9) (10)	2 (Oism 2) (Oism f)	3 (7) (8) (19)
Anterior external tergo-sternals.	—	—	1 (62)	1 (Oism 1)	—	—	—	—	2 (11) (12)	2 (Odom α) (Odom α)	—

Posterior tergo-sternals.	1(14)	2(12) (13)	2(78) (101)	2(Iism) (Iifm)	1(17)	1(15)	1(59)	1(13)	1(13)	1(Iism)	1(21)
Tergo-Pleural Muscles.											
Anterior tergo-pleurals.	—	—	—	2(Oidvm 1) (Oidvm 2)	1(18)	1(16)	1(57)	—	1(14)	1(Ovlm 5a)	3(5) (6) (24)
Ordinary tergo-pleurals.	1(15)	2(14) (15)	2(74) (75)	—	—	—	—	—	—	1(Ipm 12)	1(XXVIII)
Sterno-Pleural Muscles.											
Furco-entopleurals.	1(16)	1(16)	—	1(Izm)	1(19)	—(x)	—(x)	1(14)	1(15)	1(Izm 1)	1(XXIX)
Coxal Muscles.											
Tergal promotors.	3(17) (18) (19)	4(17) (18) (19) (20)	1(81)	2(Idvm 1) (Idvm 6)	1(20)	1(17)	1(62)	1(15)	1(16)	1(Idvm 1)	1(22)
Pleural promotors.	—	—	1(82)	—	—	1(18)	—	—	—	1(Ipm 5)	1(27)
Anterior (cervical) sternal promotors.	—	1(21)	—	—	—	—	—	1(16)	1(17)	1(Ovlm 2)	1(13)
Ordinary sternal promotors.	1(20)	1(22)	1(86)	2(Ibm 1) (Ibm 3)	1(21)	1(19)	—	1(17)	1(18)	1(Ibm 1)	1(28)
Tergal remotors.	3(21) (22) (23)	6(23) (24) (25) (26) (27) (28)	3(83) (84) (85)	3(Idvm 3+4) (Idvm 2) (IIdvm 2a)	3(22) (23) (24)	3(20) (21) (22)	3(63) (64) (65)	3(18) (19) (20)	3(19) (20) (21)	3(Idvm 2) (Idvm 7) (Ipm 6)	4(23) (23a) (24) (24a)
Posterior spinal remotors.	2(24) (25)	—	—	—	2(25) (26)	3(23)	1(67)	—	1(22)	1(Ibm 7)	1(31)
Ordinary sternal remotors.	—	1(29)	1(87)	—	—	—	1(66)	1(21)	1(23)	1(Ibm 2)	1(29)
Pleural adductors.	—	—	1(91)	1(IIdvm 2)	—	—	—	—	—	—	—
Sternal adductors.	1(26)	1(30)	1(90)	1(Ibm 2)	1(27)	1(24)	1(69)	1(22)	1(24)	1(Ibm 3)	1(30)
Tergal abductors.	2(27) (28)	1(31)	1(88)	1(IIdvm 1)	—	—	—	—	—	—	—
Pleural abductors.	2(29) (30)	1(32)	1(89)	1(Ipm 5)	2(28) (29)	2(25) (26)	2(68a) (68b)	2(23) (14)	2(25) (26)	1(Ipm 4)	1(26)
Trochanteral Muscles Arising on the Thorax.											
Tergal depressors.	1(31)	3(33) (34) (35)	—	1(Idvm 5)	1(30)	1(27)	1(71d)	1(25)	1(27)	3(Idvm 5) (Idvm 8) (Ipm 6a)	2(25b) (25d)
Pleural depressors.	1(32)	1(36)	1(92)	1(IIdvm 3)	2(31) (32)	1(28)	2(71b) (71c)	2(26) (27)	3(28) (29) (30)	1(Ipm 4a)	4(25) (25a) (25c) (25e)
Sternal depressors.	—	—	—	—	—	1(29)	—	1(28)	1(31)	1(Ibm 4)	—

b) Mesothoracic Musculature

	Blattidae. *Periplaneta australasia.* (Fig. 6)	Mantidae. *Hierodula patellifera* (Fig. 7)	Phasmidae. *Megacrania tsudai* (MAKI, 1935)	Phasmidae. *Dixippus morosus* (JEZIORSKI, 1918)	Acridiidae. *Locusta migratoria manilensis* (Fig. 8)	Acridiidae. *Atractomorpha ambigua* (Fig. 9)	Acridiidae. *Dissosteira carolina* (SNODGRASS, 1929)	Tettigonidae. *Xiphidion maculatum* (Fig. 10)	Gryllidae. *Brachytrupes portentosus* (Fig. 11)	Gryllidae. *Gryllus domesticus* (VOSS, 1905)	Gryllidae. *Gryllus assimilis* (DU PORTE, 1920)
Dorsal Muscles.											
Median dorsals.	2(33) (34)	1(37)	2(93) (95)	2(dlm 2) (dlm 1)	2(33) (34)	2(30) (31)	1(81)	1(29)	1(32)	1(II dlm 1) (II dlm 2)	1(36, 35)
Lateral dorsals.	2(35) (36)	2(38) (39)	2(94) (96)	2(dlm 3) (dlm 4)	2(35) (36)	—	1(82)	1(30)	1(33)	1(II dlm 3) (II dlm 4)	1(XXXVI)
Dorsal Transverse Muscles.	1(37)	—	—	—	—	—	—	—	—	—	—
Ventral Muscles.											
Longitudinal ventrals.	1(38)	1(40)	—	—	1(37)	1(32)	1(60)	1(31)	1(34)	1(Ivlm 4+5)	1(16)
Unpaired median longitudinal ventrals.	1(39)	1(41)	—	—	1(38)	—	1(88)	1(32)	1(35)	1(Ivlm 1)	1(XIII)
Profurco-metaspinal ventrals.	—	—	—	—	—	—	—	—	1(36)	1(Ivlm 6)	1(17)
Mesospino-mesofurcal ventrals.	—	1(42)	—	—	1(39)	1(33)	1(87)	1(33)	1(37)	1(Ivlm 3)	1(15)
Anterior short ventrals.	—	—	1(98)	1(vlm)	—	—	—	—	—	—	—
Posterior ventrals.	—	1(43)	—	—	—	—	—	—	—	—	—
Ventral Transverse Muscles.											
Anteriors.	1(40)	1(44)	—	—	—	—	—	1(34)	—	—	—
Posteriors.	1(41)	—	1(99)	—	—	—	—	1(35)	—	—	—
Tergo-Sternal Muscles.											
Anteriors.	1(42)	1(45)	1(102)	1(IIsm 2)	3(40) (41) (42)	3(34) (35) (36)	2(83) (84)	1(36)	1(38)	1(IIdvm 7)	1(45)
Posteriors.	1(43)	2(46) (47)	1(100)	1(IIism 1)	1(43)	—	—	—	1(39)	1(IIism)	1(37)
Tergo-Pleural Muscles.											
Ordinary tergo-pleurals.	4(44) (45) (46) 47	3(48) (49) 50	1(104) (105)	—	3(44) (45) 46	—	—	2(37) (38)	1(40)	3(IIpm 11) (IIpm 9) (IIpm 10)	2(47) (49)
Pleuro-axillary muscles.	1(48)	1(51)	2(114) (115)	—	1(47)	2(37) 38	1(85)	1(39)	1(41)	2(IIpm 12) (IIpm 13)	1(48)
Pleuro-subalar muscles.	—	—	1(106)	—	1(48)	—	—	—	—	1(IIpm 7)	—

Sterno-Pleural Muscles.											
Ordinary sterno-pleurals.	—	—	3(107) (108) (109)	1(IIIdvm)	—	—	—	—	—	2(IIpm 5d) (IIpm 5e)	—
Sterno-basalar muscles.	—	—	1(110)	—	1(49)	1(39)	1(97)	—	1(42)	1(IIpm 14)	1(46)
Furco-entopleural muscles.	1(49)	1(52)	1(111)	1(IIzm)	1(50)	1(40)	1(86)	1(40)	1(43)	1(IIzm)	1(LI)
Coxsal Muscles, Coxsal and Trochantinal Wing Muscles.											
Tergal promotors of the coxa.	1(50)	2(53) (54)	1(116)	1(IIdvm 6)	1(51)	1(41)	1 (89)	1(41)	1(44)	2(IIdvm 1) (IIdvm 6)	2(38) (38a)
Pleural promotors of the coxa.		1(55)	—	—	—	—	—	—	—	1(IIpm 5b)	1(43(2))
Trochanchino-basalar muscles.	1(51)	1(56)	—	—	—	—	—	1(42)	1(45)	2(IIpm 1) (IIpm 2)	1(41)
Anterior spinal promotors of the coxa.	—	—	—	—	—	—	—	1(43)	1(46)	1(Ivlm 2)	2(14) (14a)
Ordinary sternal promotors of the coxa.	1(52)	1(57)	2(119) (120)	2(IIbm 1) (IIbm 3)	1(52)	1(42)	1 (92)	1(44)	1(47)	1(IIbm 1)	1(52)
Tergal remotors of the coxa.	2(53) (54)	3(58) (59) (60)	2(117) (118)	3(IIdvm 2) (IIdvm 3+4) (IIdvm 2a)	2(53) (54)	2(43) (44)	2 (90) (91)	2(45) (46)	2(48) (49)	2(IIdvm 2) (IIpm 6)	2(39) (39a)
Coxo-subalar muscles.	1(55)	1(61)	1(127)	—	1(55)	1(45)	1 (99)	1(47)	1(50)	1(IIbm 7)	1(44)
Posterior spinal remotors of the coxa.	1(56)	1(62)	—	—	—	1(46)	1 (93)	1(48)	1(51)	1(IIbm 2)	1(LII)
Ordinary sternal remotors of the coxa.	—	1(63)	2(128) (121)	1(IIbm 2)	1(56)	1(47)	1(101)	1(49)	1(52)	1(IIbm 5)	2(53) (55)
Pleural adductors of the coxa.	—	—	1(129)	1(IIIdvm 2)	—	—	—	—	—	—	—
Sternal adductors of the coxa.	1(57)	1(64)	—	—	1(57)	1(48)	1(100)	1(50)	1(53)	2(IIbm 3) (IIbm 6)	1(54)
Tergal abductors of the coxa.	—	—	—	—	1(58)	—	—	—	—	—	—
Pleural abductors of the coxa.	2(58) (59)	2(65) (66)	3(122) (123) (124)	1(IIIdvm 1)	2(59) (60)	2(49) (50)	3 (94) (95) (96)	2(51) (52)	2(54) (55)	2(IIbm 4) (IIbm 5a)	2(42) (43 1))
Coxo-basalar muscles.	1(60)	2(67) (68)	2(125) (126)	—	1(61)	1(51)	1 (98)	1(58)	1(56)	—	—
Trochanteral Muscles Arising on the Thorax, and Trachanteral Wing Muscles.											
Tergal depressors of the trochanter.	1(61)	1(69)	1(130)	1(IIdom 5)	1(62)	2(52) (53)	2(103)	1(54)	1(57)	1(IIdvm 5)	1(40)
Pleural depressors of the trochanter.	—	—	—	1(IIIdvm 3)	—	—	—	—	—	—	—
Trochantero-basalar muscles.	2(62) (63)	1(70)	1(131)	—	—	—	—	1(55)	1(58)	1(IIpm 3)	1(40a)
Sternal depressors of the trochanter.	1(64)	1(71)	—	—	1(63)	1(54)	1(103)	1(56)	1(59)	1(IIbm 4)	1(LV)*
Muscles of the Spiracle.	1(65)	2(72) (73)	2(79) (80)	2 Istm a+b)	2(64) (65)	2(55) (56)	2 (79) (80)	1(57)	2(60) (61)	1(Istm)	2(oc. 1 sp.) (oc. 2 sp.)

c) Metathoracic Masculature

	Blattidae. *Periplaneta australasia.* (Fig. 6)	Mantidae. *Hierodula patellifera* (Fig. 7)	Phasmidae. *Megacrania tsudai* (MAKI, 1935)	Phasmidae. *Dixippus morosus* (JEZIORSKI, 1918)	Acridiidae. *Locusta migratoria manilensis* (Fig. 8)	Acridiidae. *Atractomorpha ambigua* (Fig. 9)	Acridiidae. *Dissosteira carolina* (SNODGRASS, 1929)	Tettigonidae. *Xiphidion maculatum* (Fig. 10)	Gryllidae. *Brachytrupes portentosus* (Fig. 11)	Gryllidae. *Gryllus domesticus* (VOSS, 1905)	Gryllidae. *Gryllus assimilis* (DU PORTE, 1920)
Dorsal Muscles.											
Median dorsals.	2(66) (67)	1(74)	2(133) (135)	—	1(66)	2(57) (58)	1(112)	1(58)	1(62)	2(IIIdlm 1) (IIIdlm 1a)	1(57)
Lateral dorsals.	2(68) (69)	1(75)	2(134) (136)	—	—	—	—	—	—	2(IIIdlm 3) (IIIdlm 4)	—
Dorsal Transverse Muscles.	1(70)	1(76)	—	—	—	—	—	—	—	—	
Ventral Muscles.											
Longitudinal ventrals.	1(71)	1(77)	2(138) (139)	1(IIIvlm)	1(67)	—	1(116)	1(59)	1(63)	1(IIvlm 4+5)	1(34)
Unpaired median longitudinal ventrals.	1(72)	—	—	..	—	—	—	—	—	—	—
Metaspino-metafurcal ventrals.	1(73)	1(78)	—	—	1(68)	—	1(117)	1(60)	1(64)	1(IIvlm 3)	1(33)
Ventral Transverse Muscles.											
Anteriors.	1(74)	—	—	—	1(69)	—	—	1(61)	1(65)	1(IIifm)	1(51)
Posteriors.	—	—	1(140)	—	1(70)	1(59)	—	—	—	—	—
Tergo-Sternal Muscles.											
Anterior tergo-sternals.	—	—	1(142)	1(IIism 2)	1(71)	1(60)	1(113)	—	—	—	—
Posterior tergo-sternals.	1(75)	1(79)	1(141)	1(IIIism 1)	1(72)	1(61)	—	—	1(66)	1(IIIism)	1(58)
Tergo-Pleural Muscles.											
Ordinary tergo-pleurals.	4(76) (77) (78) (79)	3(80) (81) (82)	5(143) (144) (145) (146) (a part of 147)	—	3(73) (74) (75)	—	—	1(62)	1(67)	4(IIIpm 8) (IIIpm 9) (IIIpm 10) (IIIpm 11)	1(68)
Pleuro-axillary muscles.	1(80)	1(83)	2(153) (154)	—	1(76)	2(62) (63)	1(114)	1(63)	1(68)	1(IIIpm 12)	1(67)
Pleuro-subalar muscles.	—	—	1(a part of 147)	—	—	—	—	1(64)	1(69)	1(IIpm 7)	1(66)

Sterno-Pleural Muscles.											
Ordinary sterno-pleurals.	—	—	1(151)	1(IIildvm)	—	—	—	—	—	—	—
Sterno-basalar muscles.	—	—	3(148) (149) (150)	—	2(77) (78)	2(64) (65)	1(127)	—	—	—	—
Furco-entopleural muscles.	1(81)	1(84)	1(152)	1(IIIzm)	1(79)	1(66)	1(115)	1(65)	1(70)	1(IIIzm)	1(LXVII)
Coxal Muscles, Coxal and Trochantinal Wing Muscles.											
Tergal promotors of the coxa.	1(82)	2(85) (86)	1(155)	—	1(80)	1(67)	1(118)	1(66)	2(71) (72)	2(IIIdvm 1) (IIIdvm 2)	2(59) (59a)
Pleural promotors of the coxa.	—	1(87)	—	—	—	—	—	—	—	1(IIIpm 5b)	1(64(2))
Trochantino-basalar muscles.	1(83)	1(88)	—	—	—	—	—	1(67)	1(73)	1(IIIpm 1, 2)	1(62)
Anterior spinal promotors of the coxa.	—	—	—	—	1(81)	—	—	1(68)	1(74)	1(IIvlm 2)	1(32)
Ordinary sternal promotors of the coxa.	1(84)	1(89)	1(158)	2(IIIbm 1) (IIIbm 3)	2(82) (83)	2(68) (69)	1(121)	1(69)	1(75)	1(IIIbm 1)	1(69)
Tergal remotors of the coxa.	2(85) (86)	3(90) (91) (92)	2(156) (157)	3(IIIdvm 2) (IIIdvm3+4) (IIIldvm 2a)	3(84) (85) (86)	2(70) (71)	2(119) (120)	2(70) (71)	2(76) (77)	3(IIIdvm 3) (IIIdvm 4) (IIIdvm 2)	2(60) (60a)
Coxo-subalar muscles.	1(87)	1(93)	1(164)	—	1(87)	1(72)	1(129)	1(72)	1(78)	1(IIIpm 6)	1(65)
Ordinary sternal remotors of the coxa.	2(88) (89)	1(94)	2(165) (159)	1(IIIbm 2)	2(88) (89)	2(73) (74)	3(122) (123) (124)	2(73) (74)	2(79) (80)	2(IIIbm 2) (IIIbm 5)	2(70) (72)
Pleural adductors of the coxa.	—	—	1(166)	1(IIIbm 2)	—	—	—	—	—	—	—
Sternal adductors of the coxa.	1(90)	1(95)	—	—	2(90) (91)	1(75)	1(130)	1(75)	1(81)	1(IIIbm 3)	1(71)
Pleural abductors of the coxa.	2(91) (92)	2(96) (97)	2(160) (161)	2(IIIldvm 1) (IIIpm 5)	2(92) (93)	2(76) (77)	2(125) (126)	2(76) (77)	2(82) (83)	2(IIIpm 4) (IIIpm 5a)	2(63) (64(1))
Coxo-basalar muscles.	1(93)	2(98) (99)	2(162) (163)	—	1(94)	1(78)	1(128)	1(78)	1(84)	—	—
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.											
Tergal depressors of the trochanter.	1(94)	1(100)	1(167)	1(IIIdvm 2)	2(95) (96)	2(79) (80)	2(133c)	1(79)	1(85)	1(IIIdvm 5)	1(61)
Pleural depressors of the trochanter.	—	—	—	1(IIIldvm 3)	—	—	—	—	—	—	—
Trochantero-basalar muscles.	2(95) (96)	1(101)	—	—	—	—	—	1(80)	1(86)	1(IIIpm 3)	1(61a)
Sternal depressors of the trochanter.	1(97)	1(102)	1(168)	1(IIIbm 4)	1(97)	1(81)	1(133d)	1(81)	1(87)	1(IIIbm 4)	1(LXXII)
Muscles of the Spiracle.	1(98)	1(103)	2(112) (113)	2 IIIstm a+b	1(98)	1(82)	1(111)	1(82)	2(88) (89)	2(IIstm 1) (IIstm 1)	2(oc. 1 sp.) (oc. 2 sp.)

d) Abdominal Musculature

	Blattidae. *Periplaneta australasia* (Fig. 6)	Mantidae. *Hierodula patellifera* (Fig. 7)	Acridiidae. *Locusta migratoria manilensis* (Fig. 8)	Acridiidae. *Atractomorpha ambigua* (Fig. 9)	Tettigonidae. *Xiphidion maculatum* (Fig. 10)	Gryllidae. *Brachytrupes portentosus* (Fig. 11)
I Segment						
Dorsal Muscles.	3 (99) (100) (101)	3 (104) (105) (106)	3 (99) (100) (101)	2 (83) (84)	1 (83)	3 (90) (91) (92)
Dorsal Transverse Muscles.	1 (102)	1 (107)	1 (102)	1 (85)	1 (84)	1 (93)
Ventral Muscles.	2 (103) (104)	2 (108) (109)	3 (103) (104) (105)	3 (86) (87) (88)	4 (85) (86) (87) (88)	2 (94) (95)
Ventral Transverse Muscles.	1 (105)	—	—	—	—	—
Tergo-Sternal Muscles.	—	1 (110)	3 (106) (107) (108)	2 (89) (90)	1 (89)	2 (96) (97)
Occlusor of the Spiracle.	1 (106)	1 (111)	1 (109)	1 (91)	1 (90)	1 (98)
Dilator of the Spiracle.	—	1 (112)	—	—	—	1 (99)
II Segment						
Dorsal Muscles.	2 (107) (108)	3 (113) (114) (115)	2 (110) (111)	2 (92) (93)	1 (91)	2 (100) (101)
Dorsal Transverse Muscles.	1 (109)	1 (116)	1 (112)	1 (94)	1 (92)	1 (102)
Ventral Muscles.	2 (110) (111)	3 (117) (118) (119)	3 (113) (114) (115)	3 (95) (96) (97)	4 (93) (94) (95) (96)	3 (103) (104) (105)
Ventral Transverse Muscles.	1 (112)	—	1 (116)	1 (98)	1 (97)	1 (106)
Tergo-Sternal Muscles.	1 (113)	4 (120) (121) (122) (123)	4 (117) (118) (119) (120)	3 (99) (100) (101)	3 (98) (99) (100)	1 (107) (108) (109) (110)
Tergo-Pleural Muscles.	—	—	—	—	—	2 (111) (112)
Sterno-Pleural Muscles.	—	—	—	—	—	2 (113) (114)
Occlusor of the Spiracle.	1 (114)	1 (124)	1 (121)	1 (102)	1 (101)	1 (115)
Dilator of the Spiracle.	1 (115)	1 (125)	1 (122)	1 (103)	1 (102)	1 (116)

III-VI Segments

Each musculature is very similar to the musculature of II Segment, but additionally provided with two pairs of tergo-sternals in the *Locusta* (Fig. 8, *123*, *124*) and *Atractomorpha* (Fig. 9, *104*, *105*), and one pair of ventral muscles in the *Brachytrupes* (Fig. 11, *117*).

Megacrania are two-bundled. The pleural abductors of the coxae and coxo-basalar muscles correspond to those of the mesothorax respectively: In the *Periplaneta* Fig. 6, **91, 92, 93** to **58, 59, 60**; in the *Hierodula* Fig. 7, **96, 97** and **98, 99** to **65, 66,** and **67, 68**; in the *Locusta* Fig. 8, **92, 93,** and **94** to **59, 60,** and **61**; in the *Atractomorpha* Fig. 9, **76, 77,** and **78** to **49, 50,** and **51**; in the *Xiphidion* Fig. 10, **76, 77,** and **78** to **51, 52,** and **53**; in the *Brachytrupes* Fig. 11, **82, 83,** and **84** to **54, 55,** and **56.**

9) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

(*a*) *Tergal Depressors of the Trochanters*

The trochanters in the species except the *Locusta* have tergal depressors (Fig. 6, **94**; Fig. 7, **100**; Fig. 9, **79, 80**; Fig. 10, **79**; Fig. 11, **85**) corresponding to the tergal depressors of their mesothoracic trochanters (Fig. 6, **61**; Fig. 7, **69**; Fig. 9, **52, 53**; Fig. 10, **54**; Fig. 11, **57**) respectively. The *Locusta* has two tergal depressors on the trochanter (Fig. 8, **95, 96**), one similar to the tergal depressor in the mesothorax (Fig. 8, **62**), the other not found on the mesothorax, arising on the lateral portion of the tergum at the inside of the anterior notal wing process.

(*b*) *Trochantero-Basalar Muscles*

The trochantero-basalar muscles are two-paired in the *Periplaneta* (Fig. 6, **95, 96**), and one-paired in the *Hierodula* (Fig. 7, **101**), *Xiphidion* (Fig. 10, **80**) and *Brachytrupes* (Fig. 11, **86**), and are very similar to their mesothoracics (Fig. 6, **62, 63**; Fig. 7, **70**; Fig. 10, **55**; Fig. 11, **58**) respectively.

(*c*) *Sternal Depressors of the Trochanters*

The sternal depressors are found in one pair on the seven species. The sternal depressors of the species except the *Megacrania* (Fig. 6, **97**; Fig. 7, **102**; Fig. 8, **97**; Fig. 9, **81**; Fig. 10, **81**; Fig. 11, **87**) correspond to those of the mesothorax (Fig. 6, **64**; Fig. 7, **71**; Fig. 8, **63**; Fig. 9, **54**; Fig. 10, **56**; Fig. 11, **59**) respectively.

10) Muscles of the Second Thoracic Spiracles

The second thoracic spiracle in the *Megacrania* and *Brachytrupes*

has two occlusors (Fig. 11, 88, 89), in the *Periplaneta* (Fig. 6, 98) and *Xiphidion* (Fig. 10, 82), *Hierodula* (Fig. 7, 103), *Locusta* (Fig. 8, 98) and *Atractomorpha* (Fig. 9, 82) has an occlusor. All these occlusors, except the first occlusor in the *Brachytrupes* (Fig. 11, 88) arising on the posterior portion of the subspiraculare and attached on the anterior lip of the spiracle, arise on the ventral portions of the subspiracular sclerites and attach on the ventral ends of the spiracles.

The thoracic musculatures of the seven species are shown in Table II, including those of some other species observed by other authors.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figs. 6-11 and Table II.

2. DERMAPTERA

Labiduridae. *Anisolabis annulipes* LUCAS (Fig. 12)
Labiidae. *Labia curvicauda* MOTSCHULSKY (Fig. 13)

a. Prothoracic Musculature

The prothoracic musculature in the wingless Dermaptera, *Anisolabis annulipes* (Fig. 12), and in the winged one, *Labia curvicauda* (Fig. 13), are very similar to each other.

1) Dorsal Muscles

The dorsal muscles are found in three pairs, median, lateral, and anterior, The median dorsal muscle (Fig. 12, **1**; Fig. 13, **1**) is very long, fan-shaped, attached anterioly on the apodeme on the anterior dorsal mebrane of the cervical region, and posteriorly on the phragma near the dorsal median line by a broad base. The lateral dorsal muscle (Fig. 12, **2**; Fig. 13, **2**) is strong, oblique, fan-shaped, arising on the anterior median portion of the tergum along the dorsal median ridge and inserted into the antero-lateral corner of the mesotergum. The anterior dorsal muscle (Fig. 12, **3**; Fig. 13, **3**) is longitudinal,

attached anteriorly on the apodeme of the anterior cervical dorsal membrane with the median dorsal muscle and posteriorly on the posterior (*Anisolabis*) or the middle (*Labia*) of the median region of the tergum.

2) **Ventral Muscles**

Three ventral muscles are found on each side, internal, external, and anterior. The internal ventral muscle (Fig. 12, **4**; Fig. 13, **4**) is long, longitudinal, fan-shaped, attached anteriorly on the posterior ventral end of the head at the outside of the postero-lateral corner of the submentum and posteriorly on the furcal arm by a broad base. The external ventral muscle (Fig. 12, **5**; Fig. 13, **5**) is shorter than the internal one, longitudinal, broad, arising on the posterior margin of the ventro-lateral cervical sclerite, and inserted into the base of the furcal arm. The anterior ventral muscle (Fig. 12, **6**; Fig. 13, **6**) is oblique, fan-shaped, attached anteriorly on the position same to the attached position of the internal ventral muscle and posteriorly on the median portion of the posterior cervical ventral sclerite by a broad base.

3) **Ventral Transverse Muscles**

The ventral transverse muscles are one-paired, arising on the bases of the furcal arms and attached on the spina between the pro- and the mesosternum. (Fig. 12, **7**; Fig. 13, **7**)

4) **Tergo-Sternal Muscles**

In the tergo-sternal muscles are found four kinds, anterior inter-segmentals, anterior internals, anterior externals, and posteriors. The anterior intersegmentals are one-paired (*Labia*, Fig. 13, **8**) or two-paired (*Anisolabis*, Fig. 12, **8**, **9**), arising on the dorso-lateral portions of the posterior margin of the head and inserted into the middle or somewhat posterior portions of the ventro-lateral cervical sclerites. The anterior internals are one-paired, taking their origins on the dorso-lateral portions of the anterior region of the tergum before the transverse tergal ridge and their insertions into the inner portions of the middle regions of the ventro-lateral cervical sclerites (Fig. 12, **10**; Fig. 13, **9**). The anterior externals are one-paired, thick,

attached dorsally on the anterior portion of the tergum immediately lateral to the internal tergo-sternal muscles and ventrally on the postero-lateral portions of the ventro-lateral cervical sclerites (Fig. 12, **11**; Fig. 13, **10**). The posterior tergo-sternals are one-paired, slender, arising on the lateral portions of the anterior end of the mesotergum and attached on the bases of the profurcal arms (Fig. 12, **12**; Fig. 13, **11**).

5) Tergo-Pleural Muscles

The tergo-pleural muscles are one-paired (*Anisolabis*, Fig. 12, **13**) or two-paired (*Labia*, Fig. 13, **12, 13**), short, vertical, arising on the portions somewhat anterior to the middle portions of the dorso-lateral regions of the tergum, and inserted into the upper sides of the pleural arms.

6) Sterno-Pleural Muscles

The sterno-pleural muscles are found in one pair (Fig. 12, **14**; Fig. 13, **14**). They are slender, arising on the dorsal portions of the epimera, passing the outsides of the tergo-sternal muscles of the cervical region, and attached on the anterior portions of the ventro-lateral cervical sclerites.

7) Coxal Muscles

The prothoracic coxa has seven muscles arising on the thorax: a tergal promotor, a sternal promotor, two tergal remotors, a pleural adductor, a tergal abductor and a pleural abductor. The tergal promotor (Fig. 12, **15**; Fig. 13, **15**) is thick, arising on the anterior portion of the dorso-lateral region of the tergum behind the transverse tergal ridge by a broad base and inserted into the trochantin near the coxo-trochantinal joint. The sternal promotor (Fig. 12, **16**; Fig. 13, **16**) is a small muscle arising on the base of the furcal arm and inserted into the coxal margin at the coxo-trochantinal joint. The tergal remotors are divisible into two, internal and external; the internal muscle (Fig. 12, **17**; Fig. 13, **17**) is very thick, originating on the median anterior region of the tergum, and inserted into the posterior basal rim of the coxa, the external muscle (Eig. 12, **18**; Fig. 13, **18**) arises on the portion somewhat anterior to the middle

of the lateral region of the tergum, and is inserted into the postero-lateral basal rim of the coxa. The pleural adductor is a muscle arising on the pleural arm and inserted into the median basal rim of the coxa (Fig. 12, **19**; Fig. 13, **19**). The tergal abductor is thick, originating on the anterior of the dorso-lateral region of the tergum and attached on the antero-lateral basal rim of the coxa (Fig. 12, **20**; Fig. 13, **20**). The pleural abductor is very thick, taking its origin on the antero-dorsal portion of the episternum and is inserted into the antero-lateral basal rim of the coxa (Fig. 12, **21**; Fig. 13, **21**).

8) **Trochanteral Muscles Arising on the Thorax**

The trochanter has three muscles arising on the thorax, a tergal depressor, a pleural depressor and a sternal depressor. The tergal depressor arises on the middle or somewhat anterior portion of the dorso-lateral region of the tergum, passes behind the sterno-pleural bridge, and is attached to the common depressor apodeme on the ventral base of the trochanter (Fig. 12, **22**; Fig. 13, **22**). The pleural depressor takes its origin on the under side of the base of the pleural arm, and is inserted into the common depressor apodeme of the trochanter (Fig. 12, **23**; Fig. 13, **23**). The sternal depressor is slender, arising on the furcal arm attached on the common depressor apodeme of the trochanter. (Fig. 12, **24**; Fig. 13, **24**).

b. Mesothoracic Musculature

Although the wingless insect, *Anisolabis*, and the winged insect, *Labia*, are different from each other in the body structure they have musculatures very similar to each other.

1) **Dorsal Muscles**

Two pairs of dorsal muscles are found, median and lateral. The median pair are longitudinal, thick especially in the *Anisolabis*, stretching between the first and the second phragmata (Fig. 12, **25**; Fig. 13, **25**). The lateral pair are oblipue, fan-shaped, arising on the middle of the median region of the tergum, and inserted into the antero-lateral corners of the metatergum. (Fig. 12, **26**; Fig. 13, **26**).

2) Ventral Muscles

Three ventral muscles are found on each side, longitudinal ventral, oblique profurco-metaspinal ventral and oblique mesospino-metasternal ventral. The longitudinal ventral muscle is thick, stretching btween the pro- and mesofurcal arms (Fig. 12, **27**; Fig. 13, **27**). The oblique profurco-metaspinal ventral muscle is very slender, attached anteriorly on the base of the profurcal arm and posteriorly on the spina at the anterior end of the median region of the metasternum (Fig. 12, **28**; Fig. 13, **28**). The oblique mesospino-metasternal ventral muscle is very slender, arising on the spina at the anterior median portion of the sternum, and inserted into the lateral portion of the anterior margin of the metasternum (Fig. 12, **29**; Fig. 13, **29**).

3) Ventral Transverse Muscles

In the ventral transverse muscles are found two kinds, anteriors and posteriors. The anterior ventral transverse muscles are one-paired (*Anisolabis*, Fig. 12, **30**) or two-paired (*Labia*, Fig. 13, **30, 31**). They arise on the intersegmental membranes before the pleuron and take their insertions into the spina on the anterior median portion of the sternum. The posterior ventral transverse muscles are one-paired, rising on the furcal arms and inserted into the spina on the median portion of the anterior end of the metasternum (Fig. 12, **31**; Fig. 13, **32**).

4) Tergo-Sternal Muscles

There are found one pair of the posterior tergo-sternal muscles which are attached dorsally on the lateral portions of the anterior end of the metatergum and ventrally on the mesofurcal arms (Fig. 12, **32**; Fig. 13, **33**).

5) Tergo-Pleural Muscles

In the tergo-pleural muscles are found two kinds, ordinary tergo-pleural muscles and pleuro-axillary muscles. The ordinary tergo-pleurals are three-paired (*Anisolabis*, Fig. 12, **33, 34, 35**; *Labia*, Fig. 13, **34, 35, 36**); the first pair are slender, arising on the anterior end of the tergum at both sides of the median line, and inserted into the antero-dorsal portions of the episterna, the second arise on the anterior

ends (*Anisolabis*, Fig. 12, **34**) or the middle portions (*Labia*, Fig. 12, **35**) of the dorso-lateral regions of the tergum, and are inserted into the pleural arms, the third are very broad (*Anisolabis*, Fig. 12, **35**) or slender (*Labia*, Fig. 13, **36**), arising on the middle (*Anisolabis*) or posterior portions of the dorso-lateral regions of the tergum, and attached on the upper sides of the pleural arms. The pleuro-axillary muscles are found on the *Labia*, but are lacking in the wingless insect, *Anisolabis*; these are very small, arising on the dorsal portions of the epimera along the pleural ridges, and inserted into the bases of the upper sides of the wings. (Fig. 13, **37**).

6) **Sterno-Pleural Muscles**

On each side there is a tergo-pleural muscle stretched between the furcal arm and the pleural arm (Fig. 12, **36**; Fig. 13, **38**).

7) **Pleural Muscles**

Very thinly layered muscles stretched between the episterna and the precoxal sclerites are found on the *Anisolabis* (Fig. 12, **37**), but lacking in the *Labia*.

8) **Coxal Muscles and Coxal Wing Muscles**

On each side there are coxal muscles as follows: A tergal promotor, two sternal promotors, one (*Labia*) or two (*Anisolabis*) tergal remotors, a sternal remotor, a sternal adductor and two pleural abductors. In the winged insect, *Labia*, there are also a coxo-subalar muscle and a coxo-basalar muscle on each side.

The tergal promotor of the coxa (Fig. 12, **38**; Fig. 13, **39**) is very similar to that in the prothorax.

In the sternal promotors are found two kinds, an anterior spinal promotor and an ordinary sternal promotor; the anterior spinal promotor (Fig. 12, **39**; Fig. 13, **40**) is very slender, arising on the spina of the anterior end of the sternum, and inserted into the trochantin near the coxo-trochantinal joint; the ordinary sternal promotor (Fig. 12, **40**; Fig. 13, **41**) is very small, stretching between the base of the furcal arm and the anterior basal margin of the coxa.

The first tergal remotor (Fig. 12, **41**) of the *Anisolabis* is internal, the second (Fig. 12, **42**) is external, both being very similar

to the internal and the external tergal remotor (Fig. 12, **17, 18**) in the prothorax respectively. The tergal remotor (Fig. 13, **42**) of the *Labia* is similar to the first tergal remotor of the *Anisolabis*. The coxo-subalar muscle (Fig. 12, **43**) of the *Labia* is stretched between the postero-lateral basal rim of the coxa and the posterior end of the wing base; this muscle is probably homologous to the external tergal remotor in the pro- and the mesothorax of the *Anisolabis* and in the prothorax of the *Labia*, and to the coxo-subalar muscle in other insects.

The sternal remotor is an ordinary sternal remotor arising on the base of the furcal arm and inserted into the posterior basal rim of the coxa (Fig. 12, **43**; Fig. 13, **44**).

The sternal adductor is small, arising on the furcal arm and inserted into the inner basal rim of the coxa (Fig. 12, **44**; Fig. 13, **45**).

The pleural abductors are two-bundled in the *Anisolabis* (Fig. 12, **45, 46**) and one-bundled in the *Labia* (Fig. 13, **46**). The first pleural abductor of the *Anisolabis* and the pleural abductor of the *Labia* are similar to each other, fan-shaped, strong, arising on the episterna along the pleural ridges, and inserted into the antero-lateral basal rims of the coxae by tendons, the second abductor of the *Anisolabis* is thick, longer than the first, arising on the antero-dorsal portion of the episternum and inserted into the antero-lateral basal rim of the coxa as the first. The coxo-basalar muscle in the *Labia* (Fig. 13, **47**) is similar to the second pleural abductor of the coxa in the *Anisolabis* except that the coxo-basalar muscle attaches dorsally on the flexibe dorsal marginal portion of the episternum, probably the coxo-basalar muscle is homologous to the second pleural abductor.

9) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

The *Anisolabis* has three trochanteral muscles arising on the the thorax on each side, a tergal, a pleural and a sternal depressor. The tergal depressor (Fig. 12, **47**) arises on the anterior of the dorso-lateral region of the tergum, runs downwards before the furco-ento-pleural muscle, and is inserted into the common depressor apodeme

on the ventral base of the trochanter. The pleural depressor (Fig. 12, **48**) arises on the antero-dorsal portion of the episternum, the sternal depressor (Fir. 12, **49**) on the furcal arm, both are inserted into the common depressor apodeme of the trochanter.

The *Labia* has two trochanteral muscles (Fig. 13, **48, 50**) similar to the tergal and the sternal depressor in the *Anisolabis*, and a trochantero-basalar muscle (Fig. 13, **49**) resemblant to the pleural depressor of the *Anisolabis* but attached dorsally on the flexible dorsal marginal portion of the episternum, on each side.

10) Muscles of the Spiracle

The first thoracic spiracle has two occlusors (Fig. 12, **50, 51**; Fig. 13, **51, 52**) very similar to those in the *Megacrania* in Orthoptera.

c. Metathoracic Musculature

1) Dorsal Muscles

The metathoracic dorsal muscles are (Fig. 12, **52, 53, 54**; Fig. 13, **53, 54**) similar to the mesothoracics, except that the lateral dorsals in the *Anisolabis* are two-paired (Fig. 12, **53, 54**).

2) Ventral Muscles

A longitudinal ventral and an oblique spino-furcal ventral muscle are found on each side of the *Anisolabis* and *Labia*, and an oblique sterno-furcal ventral muscle also on each side of the latter species. The longitudinal ventral muscle (Fig. 12, **55**; Fig. 13, **55**) is very similar to that in the mesothorax. The oblique spino-furcal ventral muscle is slender, arising on the spina on the anterior end of the median region of the sternum, and inserted into the anterior branch of the furcal arm (Fig. 12, **56**; Fig. 13, **56**). The oblique sterno-furcal ventral muscle is very slender, originated on the lateral portion of the anterior end of the sternum and inserted into the anterior branch of the furcal arm (Fig. 17, **57**).

3) Ventral Transverse Muscles

The ventral transverse muscles are one-paired in the *Labia* (Fig. 13, **57**), but lack in the *Anisolabis*. These muscles correspond to the anterior ventral transverse muscles of the mesothorax.

4) Tergo-Sternal Muscles

A posterior tergo-sternal muscle (Fig. 12, **58**; Fig. 13, **59**) very similar to that in the mesothorax is found on each side. An anterior tergo-sternal muscle arising on the anterior end of the dorsolateral region of the tergum and inserted into the sternum before the base of the furcal arm is also found on each side of the metathorax of the *Labia* (Fig. 13, **58**).

5) Tergo-Pleural Muscles

The tergo-pleural muscles in the *Anisolabis* (Fig. 12, **59, 60, 61**) are similar to those in its mesothorax, except that the second (**60**) is smaller and attached ventrally on a more anterior position than that of the mesothorax (Fig. 12, **34**). The *Labia* has three muscles belonging to the tergo-pleural muscles: The first ordinary tergo-pleural muscle (Fig. 13, **60**) corresponding to that in its mesothorax and to that in the meso- and metathorax of the *Anisolabis;* the second ordinary tergo-pleural muscle (Fig. 13, **61**) attached dorsally on the anterolateral region of the tergum and ventrally on the pleural ridge near the pleural wing process; the pleuro-axillary muscle (Fig. 13, **62**) corresponding to that in the mesothorax but inserted into the innerest wing basal sclerite very similar to the so-colled first axillary in other insects.

6) Pleural Muscles

A pleural muscle (Fig. 12, **63**; Fig. 13, **63**) very similar to that in the mesothorax of the *Anisolabis* (Fig. 12, **37**) is found on each side.

7) Coxal Muscles, Coxal and Trochantinal Wing Muscles

The metathorax of the *Anisolabis* has coxal muscles (Fig. 12, **64, 66, 67, 68, 69, 70, 71, 72, 73**) very similar to those of the mesothorax (Fig. 12, **38, 39, 40, 41, 42, 43, 44, 45, 46**) respectively, and a pair of pleural promotors (Fis. 12, **65**) lacking in the mesothorax. Each of the last muscles (Fig. 12, **65**) arises on the anterior portion of the episternum and is inserted into the trochantin before the attached portion of the other promotors of the coxa. The metathorax of the *Labia* has nine muscles (Fig. 13. **64, 66, 67, 68, 69, 70, 71, 72, 73**)

very similar to the muscles attached on the mesocoxa (Fig. 13, **39, 40, 41, 42, 43, 44, 45, 46, 47**) respectively, and a trochantino-basalar muscle (Fig. 13, **65**) stretched between the trochantin and the basalar sclerite and probably homologous to the pleural promotor of the coxa in the *Anisolabis* (Fig. 12, **65**).

8) **Trochanteral Muscles Arising on the Thorax and Trochantero-Basalar Muscles**

The *Anisolabis* (Fig. 12, **74, 75, 76**) has three depressors very similar to those in the mesothorax (Fig. 12, **47, 48, 49**) respectively, on the trochanter. The *Labia* has two depressors of the trochanter (Fig. 13, **74, 76**) and a trochantero-basalar muscle (Fig. 13, **75**) very similar to those in the mesothorax (Fig. 13, **48, 50**, and **49**) respectively, on the trochanter.

9) **Muscles of the Spiracles**

The second thoracic spiracle has an occlusor on its ventral side. The occlusor in the *Anisolabis* (Fig. 12, **77**) arises on the antero-lateral corner of the metasternum, and that in the *Labia* (Fig. 13, **77**) on the ventral portion of the subspiraculare.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figs. 12–13 and Table III.

TABLE III

Dermaptera

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figures; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Labiduridae. *Anisolabis annulipes* (Fig. 12)	Labiidae. *Labia curvicauda* (Fig. 13)
Dorsal Muscles.		
Median dorsals.	1 (1)	1 (1)
Lateral dorsals.	1 (2)	1 (2)
Anterior dorsals.	1 (3)	1 (3)
Ventral Muscles.		
Internal ventrals.	1 (4)	1 (4)
External ventrals.	1 (5)	1 (5)
Anterior ventrals.	1 (6)	1 (6)
Ventral Transverse Muscles.	1 (7)	1 (7)
Tergo-Sternal Muscles.		
Anterior intersegmental tergo-sternals.	2 (8) (9)	1 (8)
Anterior internal tergo-sternals.	1(10)	1 (9)
Anterior external tergo-sternals.	1(11)	1(10)
Posterior tergo-sternals.	1(12)	1(11)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	1(13)	2(12) (13)
Sterno-Pleural Muscles.		
Anterior sterno-pleural muscles.	1(14)	1(14)
Coxal Muscles.		
Tergal promotors.	1(15)	1(15)
Ordinary sternal promotors.	1(16)	1(16)
Tergal remotors.	2(17) (18)	2(17) (18)
Pleural adductors.	1(19)	1(19)
Tergal abductors.	1(20)	1(20)
Pleural abductors.	1(21)	1(21)
Trochanteral Muscles Arising on the Thorax.		
Tergal depressors.	1(22)	1(22)
Pleural depressors.	1(23)	1(23)
Sternal depressors.	1(24)	1(24)

b) Mesothoracic Musculature

Dorsal Muscles.		
Median dorsals.	1(25)	1(25)
Lateral dorsals.	1(26)	1(26)
Ventral Muscles.		
Longitudinal ventrals.	1(27)	1(27)
Profurco-metaspinal ventrals.	1(28)	1(28)
Mesospino-metasternal ventrals.	1(29)	1(29)
Ventral Transverse Muscles.		
Anteriors.	1(30)	2(30) (31)
Posteriors.	1(31)	1(32)

	Labiduridae. *Anisolabis annulipes* (Fig. 12)	Labiidae. *Labia curvicauda* (Fig. 13)
Tergo-Sternal Muscles.		
Posterior tergo-sternals.	1(32)	1(33)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	3(33) (34) (35)	3(34) (35) (36)
Pleuro-axillarv muscles.	—	1(37)
Sterno-Pleural Muscles.		
Furco-entopleurals.	1(36)	1(38)
Pleural Muscles.	1(37)	—
Coxal Muscles, and Coxal Wing Muscles.		
Tergal promotors of the coxa.	1(38)	1(39)
Anterior spinal promotors of the coxa.	1(39)	1(40)
Ordinary sternal promotors of the coxa.	1(40)	1(41)
Tergal remotors of the coxa.	2(41) (42)	1(42)
Coxo-subalar muscles.	—	1(43)
Ordinary sternal remotors of the coxa.	1(43)	1(44)
Sternal adductors of the coxa.	1(44)	1(45)
Pleural Abductors of the coxa.	2(45) (46)	1(46)
Coxo-basalar muscles.	—	1(47)
Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1(47)	1(48)
Pleural depressors of the trochanter.	1(48)	—
Trochantero-basalar muscles.	—	1(49)
Sternal depressors of the trochanter.	1(49)	1(50)
Muscles of the Spiracle.	2(50) (51)	2(51) (52)

c) Metathoracic Musculature

Dorsal Muscles.		
Median dorsals.	1(52)	1(53)
Lateral dorsals.	2(53) (54)	1(54)
Ventral Muscles.		
Longitudinal ventrals.	1(55)	1(55)
Metaspino-metafurcal ventrals.	1(56)	1(56)
Metasterno-metafurcal ventrals.	1(57)	—
Ventral Transverse Muscles.		
Anteriors.	—	1(57)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	—	1(58)
Posterior tergo-sternals.	1(58)	1(59)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	3(59) (60) (61)	2(60) (61)
Pleuro-axillary muscles.	—	1(62)
Sterno-Pleural Muscles.		
Furco-entopleurals.	1(62)	—
Pleural Muscles.	1(63)	1(63)

	Labiduridae. *Anisolabis annulipes* (Fig. 12)	Labiidae. *Labia curvicauda* (Fig. 13)
Coxal Muscles, Coxal and Trochantinal Wing Muscles.		
Tergal promotors of the coxa.	1(64)	1(64)
Pleural promotors of the coxa.	1(65)	—
Trochantino-basalar muscles.	—	1(65)
Anterior spinal promotors of the coxa.	1(66)	1(66)
Ordinary sternal promotors of the coxa.	1(67)	1(67)
Tergal remotors of the coxa.	2(68) (69)	1(68)
Coxo-subalar muscles.	—	1(79)
Ordinary sternal remotors of the coxa.	1(70)	1(70)
Sternal adductors of the coxa.	1(71)	1(71)
Pleural abductors of the coxa.	2(72) (73)	1(72)
Coxo-basalar muscles.	—	1(73)
Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1(74)	1(74)
Pleural depressors of the trochanter.	1(75)	—
Trochantero-basalar muscles.	—	1(75)
Sternal depressors of the trochanter.	1(76)	1(76)
Muscles of the Spiracle.	1(77)	1(77)

d) Abdominal Musculature

I Segment.		
Dorsal Muscles.	4 (78) (79) (80) (81)	4(78) (79) (80) (81)
Dorsal Transverse Muscles.	1 (82)	—
Ventral Muscles.	2 (83) (84)	3(82) (83) (84)
Tergo-Sternal Muscles.	2 (85) (86)	1(85)
Tergo-Pleural Muscles.	1 (87)	1(86)
Occlusor of the Spiracle.	1 (88)	1(87)
Dilator of the Spiracle.	1 (89)	1(88)
II-VI Segments.		
Dorsal Muscles.	4 (90) (91) (92) (93)	5(89) (90) (91) (92) (93)
Dorsal Transverse Muscles.	1 (94)	1(94)
Ventral Muscles.	2 (95) (96)	2(95) (96)
Ventral Transverse Muscles.	1 (97) in only II segment.	—
Tergo-Sternal Muscles.	4 (98) (99) (100) (101)	2(97) (98)
Occlusor of the Spiracle.	1(102)	1(99)

3. PLECOPTERA

Perlidae. *Neoperla formosana* OKAMOTO (Fig. 14)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has four dorsal muscles on each side: a median long dorsal, a lateral internal dorsal, a lateral external dorsal, and an anterior dorsal muscle. The median long dorsal muscle is longitudinal, stretching between the first phragma and the dorsal portion of the posterior end of the head near the dorsal median line (Fig. 14, **1**). The lateral internal dorsal muscle is longitudinal, attached anteriorly on the anterior portion of the dorso-lateral cervical membrane and posteriorly on the lateral portion of the anterior end of the mesotergum (Fig. 14, **2**). The lateral external dorsal muscle is an oblique bundle of fibers arising on the posterior median portion of the tergum and inserted into the lateral portion of the anterior end of the mesotergum (Fig. 14, **3**). The anterior dorsal muscle is fan-shaped, oblique, arising on the anterior median portion of the tergum and inserted into the anterior portion of the dorso-lateral cervical membrane (Fig. 14, **4**).

2) Ventral Muscles

The ventral muscles are found in two pairs, internal and external. The internal ventral muscle is longitudinal, stretched between the furcal arm and the posterior end of the ventral region of the head (Fig. 14, **5**). The external ventral muscle attaches anteriorly on the anterior portion of the ventro-lateral cervical sclerite and posteriorly on the furcal arm (Fig. 14, **6**).

3) Tergo-Sternal Muscles

On each side are found five tergo-sternal muscles: two anterior intersegmental tergo-sternals, two anterior internal tergo-sternals and a posterior tergo-sternal. The first anterior intersegmental tergo-sternal muscle is small, arising on the lateral portion of the posterior end of the head and inserted into the anterior portion of the ventro-

lateral cervical sclerite (Fig. 14, **7**); the second takes its origin on the lateral portion of the posterior end of the head, and its insertion into the posterior portion of the ventro-lateral cervical sclerite (Fig. 14, **8**). The first anterior internal tergo-sternal muscle is very slender, arising on the antero-lateral portion of the tergum, the second is thicker than the first, arising on the tergum behind the first, both attach ventrally on the anterior end of the ventro-lateral cervical sclerite (Fig. 14, **9**, **10**). The posterior tergo-sternal muscle attaches dorsally on the antero-lateral corner of the mesotergum and ventrally on the sternum behind the furcal arm (Fig. 14, **11**).

4) **Tergo-Pleural Muscles**

The tergo-pleural muscles are two-paired. The first pair are slender, stretched between the middle portions of the lateral regions of the tergum and the middle portions of the dorsal margins of the pleura (Fig. 14, **12**). The second pair are fan-shaped, originated on the middle portions of the lateral regions of the tergum behind the first, and inserted into the pleural arms (Fig. 14, **13**).

5) **Sterno-Pleural Muscles**

The sterno-pleural muscles are one-paired, very short and stretched between the furcal arms and the pleural arms (Fig. 14, **14**).

6) **Coxal Muscles**

Ten muscles belonging to the coxal muscles are found on each side: two tergal promotors (Fig. 14, **15**, **16**), two sternal promotors (Fig. 14, **17**, **18**), three tergal remotors (Fig. 14, **19**, **20**, **21**), a sternal remotor (Fig. 14, **22**), a sternal adductor (Fig. 14, **23**) and a tergal abductor (Fig. 14, **24**). The first tergal promotor arises on the anterior portion of the dorso-lateral region of the tergum, the second on the middle portion of the median region of the tergum, both are inserted into the trochantin near the coxo-trochantinal joint. The first sternal promotor is originated on the sternum before the furcal arm, the second on the base of the furcal arm, both attach on tne anterior basal rim of the coxa at the coxo-trochantinal joint. The first and second tergal remotors are inner, arise on the middle portion and the posterior portion of the dorso-lateral region of the tergum respectively,

the third is outer, very thick, arises on the lateral region of the tergum behind the second tergo-pleural muscle (Fig. 14, **13**), and all theseare inserted into the postero-lateral basal rim of the coxa. The sternal remotor is small, stretched between the furcal arm and the posterior basal rim of the coxa. The sternal adductor is a small muscle stretched between the furcal arm and the median basal rim of the coxa. The tergal abductor is thick, arising on the middle portion of the dorso-lateral region of the tergum, and inserted into the antero-lateral basal rim of the coxa.

7) **Trochanteral Muscles Arising on the Thorax**

Two trochanteral muscles are found on each side: A tergal depressor (Fig. 14, **25**) arising on the dorso-lateral region of the tergum between the first and second tergal remotors (Fig. 14, **19, 20**) and inserted into the common depressor apodeme on the ventral base of the trochanter, and a sternal depressor (Fig. 14, **26**) originated on the furcal arm and attached on the common depressor apodeme of the trochanter.

b. Pterothoracic Musculature

The mesothoracic and the metathoracic musculature are very similar to each other.

1) **Dorsal Muscles**

Two dorsal muscles are found on each side (Fig. 14, **27, 28**; **60, 61**), the first is a very thick median longitudinal muscle stretched between the anterior portion of the tergum and the anterior end of the tergum of the following segment, the second is a lateral oblique muscle arising on the middle portion of the median region of the tergum and inserted into the lateral portion of the anterior end of the tergum of the following segment.

2) **Ventral Muscles**

Two ventral muscles are found on each side (Fig. 14, **29, 30**; **62, 63**), the first (Fig. 14, **29**; **62**) is thick, longitudinal, and stretched between the furcal arm of the preceding segment and the furcal arm

of the segment, the second (Fig. 14, **30**; **63**) is a slender spino-furcal muscle arising on the spina on the posteriar end of the preceding segment and attached on the fnrcal arm.

3) Ventral Transverse Muscles

The ventral transverse muscles are one-paired (Fig. 14, **31**; **64**), very slender, connecting the antero-lateral corners of the sternum with the spina on the posterior end of the preceding segment.

4) Tergo-Sternal Muscles

The tergo-sternal muscles are found in three pairs: Two anterior pairs and a posterior pair. The first anterior tergo-sternal muscle (Fig. 14, **32**; **65**) is small, stretched between the antero-lateral corners of the tergum and sternum, the second (Fig. 14, **33**; **66**) is very thick, attached dorsally on the anterior portion of the dorso-lateral region of the scutum and ventrally on the dorso-lateral portion of the anterior of the ventral plate. The posterior tergo-sternal muscle (Fig. 14, **34**; **67**) arises on the antero-lateral corner of the tergum of the following segment, and is inserted into the sternum behind the furcal arm (mesothorax) or into the furcal arm (metathorax).

5) Tergo-Pleural Muscles

On each side there are five tergo-pleural muscles: Three ordinary tergo-pleural muscles (Fig. 14, **35, 36, 37**; **68, 69, 70**), a pleuro-axillary muscle (Fig. 14, **38**; **71**) and a pleuro-subalar muscle (Fig. 14, **39**; **72**). The first ordinary tergo-pleural is a small muscle stretched between the lateral portion of the anterior end of the tergum and the anterior end of the pleuron, the second is a vertical slender muscle attached dorsally on the lateral marginal portion of the anterior region of the scutum and ventrally on the anterior margin of the pleuron beneath the first, the third is a very broad vertical muscle arising on the lateral portion of the middle region of the scutum, and inserted into the middle portion of the pleural ridge. The pleuro-axillary muscle is fan-shaped, arising on the dorsal portion of the episternum by a broad base, and inserted into the third axillary. The pleuro-subalar muscle is very small, takes its origin on the

dorsal margin of the epimeron, and its insertion into the posterior portion of the subalare.

6) **Sterno-Pleural Muscles**

Four sterno-pleural muscles are found on each side: An anterior sterno-pleural muscles (Fig. 14, **40**; **73**), a sterno-basalar muscle (Fig. 14, **41**; **74**), and two furco-entopleural muscles (Fig. 14, **42, 43**; **75, 76**). The anterior sterno-pleural is a very small muscle stretched between the anterior ventral portion of the pleuron, and the antero-lateral corner of the sternum. The sterno-basalar muscle is vertical, very thick, attached dorsally on the antero-dorsal portion of the episternum and ventrally on the lateral wing of the anterior region of the sternum by a broad base. In the furco-entopleural muscles there are two, dorsal and ventral; the dorsal-entopleural is a very small muscle arising on the middle portion of the pleural ridge, the ventral one is very small, arising on the ventral portion of the pleural ridge, both are inserted into the furcal arm.

7) **Pleural Muscles**

The pleural muscles are one-paired, very broad, but very short, thinly layered, stretching between the ventral margin of the episternum and the lateral margin of the ventral plate (Fig. 14, **44**; **77**).

8) **Coxal Muscles and Coxal Wing Muscles**

Ten muscles connecting the coxa with the thorax are found on each side: Two tergal promotors of the coxa (Fig. 14, **45, 46**; **78, 79**), a sternal promotor of the coxa (Fig. 14, **47**; **80**), two tergal remotors of the coxa (Fig. 14, **48, 49**; **81, 82**), a coxo-subalar muscle (Fig. 14, **50**; **83**), a sternal remotor of the coxa (Fig. 14, **51**; **84**), a sternal adductor of the coxa (Fig. 14, **52**; **85**), a pleural abductor of the coxa (Fig. 14, **53**; **86**) and a coxo-basalar muscle (Fig. 14, **54**; **87**).

The first tergal promotor (Fig. 14, **45**; **78**) is an inner thick muscle arising on the anterior portion of the dorso-lateral region of the tergum behind the second anterior tergo-sternal muscle (Fig. 14, **33**; **66**), the second (Fig. 14, **46**; **79**) is an outer slender muscle arising on the lateral portion of the tergum outside the first. Both are attached to the trochantin near the coxo-trochantinal joint. The first

tergal remotor (Fig. 14, **48**; **81**) is anterior, very thick, and takes its origin on the middle of the dorso-lateral region of the scutum. The second (Fig. 14, **49**; **82**) is posterior; it arises on the postero-lateral portion of the tergum inside the ridge of the postero-lateral scutal region. Both are inserted into the posterior basal rim of the coxa. The coxo-subalar muscle (Fig. 14, **50**; **83**) is broad, attached dorsally on the subalare posteriorly on the postero-lateral basal portion of the coxa. The pleural abductor (Fig. 14, **53**; **86**) is a fan-shaped muscle arising on the episternum forward the middle portion of the pleural ridge and inserted into the antero-lateral basal rim of the coxa. The coxo-basalar muscle (Fig. 14, **54**; **87**) is very thick, takes its rise on the basalare and its insertion into the antero-lateral basal rim of the coxa. The sternal promotor, the sternal remotor and the sternal adductor are very similar to those in the prothorax, except that the sternal promotor does not subdivide.

9) Trochanteral Muscles Arising on the Thorax and Trochantero-Basalar Muscles

Three muscles stretched between the trochanter and the thorax are found on each side, a tergal depressor of the trochanter, a trochantero-basalar muscle and a sternal depressor of the trochanter. The tergal depressor (Fig. 14, **55**; **88**) is very thick, arising on the dorso-lateral region of the tergum immediately behind the first or inner tergal promotor of the coxa (Fig. 14, **45**; **78**), the trochantero-basalar muscle (Fig. 14, **56**; **89**) is very slender, attached dorsally on the dorsal portion of the basalare, the sternal depressor (Fig. 14, **57**; **90**) is slender, originated on the furcal arm, and all these attach ventrally on the common depressor apodeme of the ventral base of the trochanter.

10) Muscles of the Spiracles

The first and second thoracic spiracle have each two occlusors (Fig. 14, **58, 59**; **91, 92**) arising on the subspiracular sclerite and attached on the ventral side of the spiracle.

TABLE IV

Plecoptera
Perlidae
Neoperla formosana (Fig. 14)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1 (1)
Lateral dorsals.	2 (2) (3)
Anterior dorsals.	1 (4)
Ventral Muscles.	
Internal ventrals.	1 (5)
External ventrals.	1 (6)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2 (7) (8)
Anterior internal tergo-sternals.	2 (9) (10)
Posterior tergo sternals.	1(11)
Tergo-Pleural Muscles.	
Ordinary tergo-pleurals.	2(12) (13)
Sterno-Pleural Muscles.	
Furco-entopleurals.	1(14)
Coxal Muscles.	
Tergal promotors.	2(15) (16)
Ordinary sternal promotors.	2(17) (18)
Tergal remotors.	3(19) (20) (21)
Ordinary sternal remotors.	1(22)
Sternal adductors.	1(23)
Tergal abductors.	1(24)
Trochanteral Muscles Arising on the Thorax.	
Tergal depressors.	1(25)
Sternal depressors.	1(26)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	1(27)	1(60)
Lateral dorsals.	1(28)	1(61)
Ventral Muscles.		
Longitudinal ventrals.	1(29)	1(62)
Spino-furcal ventrals.	1(30)	1(63)
Ventral Transverse Muscles.		
Anteriors.	1(31)	1(64)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	2(32) (33)	2(65) (66)
Posterior tergo-sternals.	1(34)	1(67)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	3(35) (36) (37)	3(68) (69) (70)
Pleuro-axillary muscles.	1(38)	1(71)
Pleuro-subalar muscles.	1(39)	1(72)
Sterno-Pleural Muscles.		
Ordinary sterno-pleurals.	1(40)	1(73)
Sterno-basalar muscles.	1(41)	1(74)
Furco-entopleurals.	2(42) (43)	2(75) (76)
Pleural Muscles.	1(44)	1(77)
Coxal Muscles and Coxal Wing Muscles.		
Tergal promotors of the coxa.	2(45) (46)	2(78) (79)
Ordinary sternal promotors of the coxa.	1(47)	1(80)
Tergal remotors of the coxa.	2(48) (49)	2(81) (82)
Coxo-subalar muscles.	1(50)	1(83)
Ordinary sternal remotors of the coxa.	1(51)	1(84)
Sternal adductors of the coxa.	1(52)	1(85)
Pleural abductors of the coxa.	1(53)	1(86)
Coxo-basalar muscles.	1(54)	1(87)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1(55)	1(88)
Trochantero-basalar muscles.	1(56)	1(89)
Sternal depressors of the trochanter.	1(57)	1(90)
Muscles of the Spiracle.	2(58) (59)	2(91) (92)

b) Abdominal Musculature

	I Segment	II–VI Segments
Dorsal Muscles.	2 (93) (94)	2(103) (104)
Dorsal Transverse Muscles.	1 (95)	1(105)
Ventral Muscles.	2 (96) (97)	2(106) (107)
Tergo-Sternal Muscles.	3 (98) (99) (100)	3(108) (109) (110)
Occlusor of the Spiracle.	1(101)	1(111)
Dilator of the Spiracle.	1(102)	—

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 14 and Table IV.

4. ISOPTERA

Metatermitidae. *Odontotermes formosanus* SHIRAKI (Fig. 15)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has four dorsal muscles on each side; the first (Fig 15, **1**) is a median longitudinal muscle attached anteriorly on the anterior median portion of the tergum and posteriorly on the first phragma by a broan base; the second (Fig. 15, **2**) is a lateral internal oblique muscle arising on the middle portion of the median region of the tergum along the median ridge, the third (Fig. 15, **3**) is a lateral external oblique muscle arising on the posterior region of the tergum along the dorsal median ridge, both are inserted into the antero-lateral corner of the mesotergum; the fourth (Fig. 15, **4**) is an anterior slender oblique muscle attached anteriorly on the lateral portion of the posterior end of the head and posteriorly on the median region of the tergum behind the anterior end of the lateral internal oblique dorsal muscle.

2) Ventral Muscles

The ventral muscles are one-paired, longitudinal, very thick, arising on the posterior end of the head immediately behind the bases of the posterior tentorial arms, and inserted into the furcal arms (Fig. 15, **5**).

3) Ventral Transverse Muscles

The ventral transverse muscle (Fig. 15, **6**) are one-paired and very similar to those of the prothorax in the Orthoptera, Dermaptera, etc.

4) Tergo-Sternal Muscles

Two anterior intersegmental tergo-sternal muscles, an anterior internal tergo-sternal muscle, and two posterior tergo-sternal muscles are found on each side. The first anterior intersegmental tergo-sternal muscle (Fig. 15, **7**) is fan-shaped, thick, arising ventrally on the anterior ventro-lateral cervical sclerite by a broad base, the second (Fig. 15, **8**) is similar to the first, arising on the posterior ventro-lateral cervical sclerite by a wide base, both are attached dorsally on the dorso-lateral portion of the posterior end of the head. The anterior internal tergo-sternal muscle (Fig. 15, **9**) is thick, stretched between the antero-median portion of the tergum behind the transverse tergal ridge and the median portion of the anterior ventro-lateral cervical sclerite. The first posterior tergo-sternal muscle (Fig. 15, **10**) is very slender, stretched between the profurcal arm and the antero-lateral corner of the mesotergum; the second (Fig. 15, **11**) is very small, connects the anterior margin of the peritreme of the first thoracic spiracle with the profurcal arm.

5) Tergo-Pleural Muscles

Two tergo-pleural muscles are found on each side, the first (Fig. 15, **12**) is an anterior intersegmental muscle arising on the dorso-lateral portion of the posterior end of the head and inserted into the pleural ridge above the pleural arm, the second (Fig. 15, **13**) is a vertical muscle originated on the antero-lateral portion of the tergum and inserted into the pleural ridge as the first.

6) Coxal Muscles

On each coxa nine muscles are attached as follows: A tergal promotor, a sternal promotor, three tergal remotors, two sternal remotors, a tergal abductor and a pleural abductor. The tergal promotor (Fig. 15, **14**) is fan-shaped, strong, arising on the anterior portion of the dorso-lateral region of the tergum outside the anterior internal tergo-sternal muscle (Fig. 15, **9**), and inserted into the trochantin near the coxo-trochantinal joint by a tendon. The sternal promotor (Fig. 15, **15**) is very small, stretched between the furca and the anterior basal rim of the coxa. The first tergal remotor (Fig. 15, **16**) is thick, arising on the anterior median portion of the tergum along the median ridge, and inserted into the posterior basal rim of the coxa; the second (Fig. 15, **17**) is fan-shaped, strong, takes its origin on the middle of the dorso-lateral region of the tergum, the third (Fig. 15, **18**) arises on the antero-lateral region of the tergum, both are inserted into the postero-lateral basal rim of the coxa. The first sternal remotor (Fig. 15, **19**) is a posterior spinal remotor originated on the base of the spina between the pro- and mesosternum, the second (Fig. 15, **20**) is an ordinary sternal remotor arising on the furcal arm, both are inserted into the postero-lateral basal rim of the coxa. The tergal abductor (Fig. 15, **21**) is thick, originated on the anterior portion of the dorso-lateral region of the tergum immediately behind the transverse tergal ridge, and inserted into the antero-lateral basal rim of the coxa. The pleural abductor (Fig. 15, **22**) arises on the base of the pleural arm and is inserted into the antero-lateral basal rim of the coxa.

7) Trochanteral Muscles Arising on the Thorax

Two trochanteral muscles arising on the thorax are found on each side: A slender tergal depressor (Fig. 15, **23**) arising on the antero-lateral portion of the tergum, passing the posterior side of the pleuro-furcal bridge and inserted into the common depressor apodeme of the ventral base of the trochanter; a thick pleural depressor (Fig. 15, **24**) originated on the ventral side of the pleural arm and attached on the common depressor apodeme as the first.

b. Pterothoracic Musculature

1) Dorsal Muscles

The pterothoracic segment has a median dorsal, a lateral internal dorsal and a lateral external dorsal muscle on each side. The median muscle (Fig. 15, **25**; **55**) is somewhat oblique, arises on the central portion of tne tergum, and attaches on the anterior end of the following tergum. The lateral internal muscle (Fig. 15, **26**; **56**) is oblique, arising on the central region of the tergum immediately lateral to the anterior end of the median muscle; the lateral external muscle (Fig. 15. **27**; **57**) is shorter and more oblique than the lateral internal, arising on the posterior portion of the dorso-lateral region of the tergum; both are inserted into the lateral portion of the anterior end of the following tergum.

2) Dorsal Transverse Muscles

In the metathorax there is a pair of dorsal transverse muscles (Fig. 15, **58**) arising on the antero-lateral corner of the tergum, diverging and inserted into the ventro-lateral portion of the dorsal vessel, but in the mesothorax lacking.

3) Ventral Muscles

The mesothorax has a longitudinal, a furco-spinal and a spino-furcal ventral muscle, and the metathorax has a longitudinal and a spino-furcal ventral muscle, on each side. The longitudinal ventral muscle (Fig. 15, **28**; **59**) is thick, arising on the furcal arm and attached on the furcal arm of the preceding segment. The spino-furcal ventral muscle (Fig. 15, **30**; **60**) is oblique, very slender, arising on the furcal arm and attached on the spina at the posterior end of the preceding sternum. The mesothoracic furco-spinal ventral (Fig. 15, **29**) is a muscle very similar to that in the *Brachytrupes portentosus* (Fig. 11, **36**).

4) Ventral Transverse Muscles

Each segment has one pair of anterior ventral transverse muscles which are very slender, stretched between the antero-ventral corner of the episternum (Fig. 15, **31**, **61**) and the spina at the anterior end of the segment.

5) **Tergo-Sternal Muscles**

The mesothorax has an anterior tergo-sternal and a posterior tergo-sternal muscle, and the metathorax has only a posterior tergo-sternal muscle, on each side. The posterior tergo-sternal muscle in the mesothorax (Fig. 15, **33**) arises on the second phragma, and in the metathorax (Fig. 15, **62**) on the lateral portion of the first abdominal tergum, both take each the insertion into the furcal arm. The mesothoracic anterior tergo-sternal muscle (Fig. 15, **32**) is thick, arises on the first phragma and attaches on the antero-lateral portion of the sternum.

6) **Tergo-Pleural Muscles**

Two ordinary tergo-pleural muscles and a pleuro-axillary muscles are found on each side. The first ordinary tergo-pleural muscle (Fig, 15, **34**; **63**) is fan-shaped, arising on the phragma at the anterior end of the tergum and inserted into the anterior margin of the pleuron by a broad base. The second (Fig. 15, **35**; **64**) is slender, attached dorsally on the lateral portion of the tergum inside the posterior notal wing process, and ventrally on the middle portion of the pleural ridge. The pleuro-axillary (Fig. 15, **36**; **65**) is a fan-shaped muscle arising on the dorsal portion of the pleural ridge by a wide base and inserted into the third axillary sclerite.

7) **Sterno-Pleural Muscles**

A furco-entopleural muscle is stretched between the pleural arm and the furcal arm (Flg. 15, **37**; **66**).

8) **Coxal Muscles and Coxal Wing Muscles**

Each side of the segment is provided with ten coxal muscles and three coxal wing muscles: A tergal promotor, two sternal promotors, two tergal remotors, two sternal remotors and three pleural abductors; a trochantino-basalar muscle, a coxo-subalar muscle, and a coxo-basalar muscle.

The tergal promotor (Fig. 15, **38**; **67**) is very thick, attached dorsally on the phragma at the anterior end of the tergum, ventrally on the trochantin near the coxo-trochantinal joint. The trochantino-basalar muscle (Fig. 15, **39**; **68**) is strong, arising on the anterior

flexible margin of the episternum by a broad base and attached on the trochantin. One bundle of the sternal promotors (Fig. 15, **40**; **69**) is an anterior spinal promotor which is slender, arises on the spina of the posterior end of the preceding sternum and attaches on the anterior proximal wall of the coxa, the other bundle (Fig. 15, **41**; **70**) is an ordinary sternal promotor arising on the median ridge of the sternum before the furca, and inserted into the anterior basal rim of the coxa near the coxo-trochantinal joint. The first tergal remotor (Fig. 15, **42**; **71**) is very thick, arising on the anterior portion of the dorso-lateral region of the scutum and inserted into the inner half of the meron of the coxa, the second (Fig. 15, **43**; **72**) is fan-shaped, arising on the scutum immediately behind the first by a broad base, and attached on the apodeme of the posterior margin of the meron. The coxo-subalar muscle (Fig. 15, **44**; **73**) is very thick, similar to that in the already mentioned insects in the attached positions. One of the mesothoracic sternal remotors is a posterior spinal remotor (Fig. 15, **45**) arising on the spina of the posterior end of the sternum and inserted into the posterior basicostal ridge of the coxa, the other is an ordinary sternal remotor (Fig. 15, **46**) stretched between the furcal arm and the lateral portion of the posterior basicostal ridge; the sternal remotors in the metathorax are ordinary sternal remotors (Fig. 15, **74**; **75**) stretched between the furcal arm and the posterior basicostal ridge. The first pleural abductor (Fig. 15, **47**; **76**) is short, fan-shaped, arising on the anterior side of the pleural arm, the second (Fig. 15, **48**; **77**) is fan-shaped, longer than the first, arises on the middle of the posterior region of the episternum along the pleural ridge, the third (Fig. 15, **49**; **78**) is fan-shaped, arising on the central region of the episternum, and the coxo-basalar muscle (Fig. 15, **50**; **79**) is long, arises on the dorsal portion of the episternum, all the four are attached on the antero-lateral basal rim of the coxa.

TABLE V

Isoptera
Metatermitidae
Odontotermes formosanus (Fig. 15)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1 (1)
Lateral dorsals.	2 (2) (3)
Anterior dorsals.	1 (4)
Ventral Muscles.	
Long longitudinal ventrals.	1 (5)
Ventral Transverse Muscles.	1 (6)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2 (7) (8)
Anterior internal tergo-sternals.	1 (9)
Posterior tergo-sternals.	2 (10) (11)
Tergo-Pleural Muscles.	
Anterior tergo-pleurals.	1 (12)
Ordinary tergo-pleurals.	1 (13)
Coxal Muscles.	
Tergal promotor.	1 (14)
Ordinary sternal promotor.	1 (15)
Tergal remotor.	3 (16) (17) (18)
Posterior spinal remotor.	1 (19)
Ordinary sternal remotor.	1 (20)
Tergal abductor.	1 (21)
Pleural abductor.	1 (22)
Trochanteral Muscles Arising on the Thorax.	
Tergal depressor.	1 (23)
Pleural depressor.	1 (24)

Pterothoracic Musculature

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	1 (25)	1 (55)
Lateral dorsals.	2 (26) (27)	2 (56) (57)
Dorsal Transverse Muscles.	—	1 (58)
Ventral Muscles.		
Longitudinal ventrals.	1 (28)	1 (59)
Furco-spinal ventrals.	1 (29)	—
Spino-furcal ventrals.	1 (30)	1 (60)
Ventral Transverse Muscles.		
Anteriors.	1 (31)	1 (61)
Tergo-sternal Muscles.		
Anterior tergo-sternals.	1 (32)	—
Posterior tergo-sternals.	1 (33)	1 (62)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	2 (34) (35)	2 (63) (64)
Pleuro-axillary muscles.	1 (36)	1 (65)
Sterno-Pleural Muscles.		
Furco-entopleural muscles.	1 (37)	1 (66)
Coxal Muscles. Coxal and Trochanteral Wing Muscles.		
Tergal promotor of the coxa.	1 (38)	1 (67)
Trochantino-basalar muscles.	1 (39)	1 (68)
Anterior spinal promotor of the coxa.	1 (40)	1 (69)
Ordinary sternal promotor of the coxa.	1 (41)	1 (70)
Tergal remotor of the coxa.	2 (42) (43)	2 (71) (72)
Coxo-subalar muscles.	1 (44)	1 (73)
Posterior spinal remotor of the coxa.	1 (45)	—
Ordinary sternal remotor of the coxa.	1 (46)	2 (74) (75)
Pleural abductor of the coxa.	3 (47) (48) (49)	3 (76) (77) (78)
Coxo basalar muscles.	1 (50)	1 (79)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1 (51)	1 (80)
Trochantero-basalar muscles.	1 (52)	1 (81)
Sternal depressor of the trochanter.	1 (53)	1 (82)
Muscles of the spiracle.	1 (54)	1 (83)

b) Abdominal Musculature

	I Segment	II-VI Segments
Dorsal Muscles.	2(84) (85)	2(90) (91)
Dorsal Transverse Muscles.	1(86)	1(92)
Ventral Muscles.	1(87)	2(93) (94)
Tergo-Sternal Muscles.	1(88)	2(95) (96)
Anterior Occlusor of the Spiracle.	1(89)	1(97)
Posterior Occlusor of the Spiracle.	—	1(98)

9) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

Each segment has a tergal and a sternal depressor of the trochanter, and a trochantero-basalar muscle, on each side. The tergal depressor (Fig. 15, **51**; **80**) is thick arises on the dorso-lateral portion of the prescutum, the trochantero-basalar muscle (Fig. 15, **52**; **81**) on the dorsal portion of the basalare, and the sternal depressor (Fig. 15, **53**; **82**) on the furcal arm, and all these are attached on the common depressor apodeme of the ventral base of the trochanter.

10) Muscles of the Thoracic Spiracles

Each thoracic spiracle has an occlusor similar to that in the Blattidae of Orthoptera.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 15 and Table V.

5. EMBIOPTERA

Oligotomidae. *Oligotoma saundersi* WESTWOOD (Fig. 16)

a. Prothoracic Musculature

1) Dorsal Muscles

Five dorsal muscles are found on each side: A median internal dorsal, two median external dorsals, a lateral oblique dorsal, and an anterior oblique dorsal. The median internal dorsal (Fig. 16, **1**) is a long muscle attached anteriorly on the dorso-lateral portion of the

posterior end of the head, the first median external dorsal (Fig. 16, 2) on the median portion of the anterior margin of the tergum, the second (Fig. 16, 3) on the about middle of the median region of the tergum behind the transverse tergal ridge, all these are inserted into the first phragma. The lateral oblique dorsal (Fig. 16, 4) is a fan-shaped muscle arising on the about middle region of the tergum behind the second median external dorsal muscle and inserted into the lateral portion of the first phragma. The anterior dorsal muscle (Fig. 16, 5) is small, attached anteriorly on the dorso-lateral portion of the posterior end of the head and posteriorly on the median portion of the anterior end of the tergum immediately forward the anterior end of the first median external dorsal muscle.

2) Ventral Muscles

The ventral muscles are found in three pairs: Two pairs of long internal ventrals and a pair of external ventrals. The first internal ventral muscle (Fig. 16, 6) arises on the ventral median portion of the posterior end of the head, the second (Fig. 16, 7) on the posterior end of the head outside the first, both are inserted into the furcal arm. The external ventral muscle (Fig. 16, 8) is slender, attached anteriorly on the median portion of the anterior ventro-lateral cervical sclerite and posteriorly on the furcal arm.

3) Ventral Transverse Muscles

The ventral transverse muscles are two-paired, the first pair (Fig. 16, 9) arise on the antero-median portion of the sternellum, the second (Fig. 16, 10) on the spina at the posterior end of the sternum, both are attached laterally on the furcal arms over the connective of each side of the ventral nerve cord.

4) Tergo-Sternal Muscles

Eight tergo-sternal muscles are found on each side: Two anterior intersegmental tergo-sternals, an anterior internal tergo-sternal, three anterior external tergo-sternals, two posterior tergo-sternals. The first anterior intersegmental tergo-sternal muscle (Fig. 16, 11) is thick and arises on the posterior portion of the anterior ventro-lateral cervical sclerite, the second (Fig. 16, 12) is very thick and originates on

the posterior ventro-lateral cervical sclerite by a wide base, both are attached dorsally on the dorso-lateral portion of the posterior end of the head. The anterior internal tergo-sternal muscle (Fig. 16, **13**) is ver tical, arising on the antero-median portion of the tergum and inserted into the median portion of the anterior ventro-lateral cervical sclerite. The first anterior external tergo-sternal (Fig. 16, **14**) is a vertical muscle arising on the anterior portion of the dorso-lateral region of the tergum and inserted into the lateral portion of the anterior ventro-lateral cervical sclerite; the second (Fig. 16, **15**) is a vertical muscle originating on the antero-median portion of the tergum outside the anterior internal tergo-sternal muscle, and inserted into the lateral portion of the posterior ventro-lateral cervical sclerite; the third (Fig. 16, **16**) is very small, attached dorsally on the middle of the lateral region of the tergum, and ventrally on the lateral portion of the posterior ventro-lateral cervical sclèrite. The first posterior tergo-sternal muscle (Fig. 16, **17**) arises on the antero-lateral corner of the mesotergum, the second (Fig. 16, **18**) is very slender, originating on the peritreme above the first thoracic spiracle, both are inserted into the profurcal arm.

5) **Tergo-Pleural Muscles**

The tergo-pleural muscles are one-paired, very broad, arising on the dorso-lateral regions of the tergum, and inserted into the dorsal margins of the pleura (Fig. 16, **19**).

6) **Coxal Muscles**

The coxa has two tergal promotor, a sternal promotor, two tergal remotors, a sternal remotor, a sternal adductor, a tergal abductor and a pleural abductor.

The first tergal promotor (Fig. 16, **20**) is an anterior bundle, the second (Fig. 16, **21**) is a posterior one, both arise on the middle portion of the median region of the tergum, and are inserted into the trochantin. The first tergal remotor (Fig. 16, **23**) is an internal fan-shaped bundle arising on the middle of the median region of the tergum immediately lateral to the lateral oblique dorsal muscle (Fig. 16, **4**); the second (Fig. 16, **24**) is an external bundle, thinner than the first, arising on the tergum outside the first; both are inserted

into the postero-lateral basal rim of the coxa. The tergal abductor (Fig. 16, **27**) is thick, arising on the antero-median region of the tergum immediately before the anterior end of the second external dorsal muscle (Fig. 16, **3**), the pleural abductor (Fig. 16, **28**) is short, thick, arising on the dorso-anterior portion of the pleuron, both are inserted into the antero-lateral basal margin of the coxa. The sternal promotor (Fig. 16, **22**), remotor (Fig. 16, **25**) and adductor (Fig. 16, **26**) are very similar to those in the *Hierodula* (Fig. 7, **22, 29, 30**) and *Xiphidion* (Fig. 10, **17, 21, 22**) respectively.

7) Trochanteral Muscles Arising on the Thorax

Two trochanteral muscles arising on the thorax are found on each side: A thick tergal depressor (Fig. 16, **29**) arising on the median region of the tergum immediately lateral to the second external dorsal muscle (Fig. 16, **13**), and a very thick pleural depressor (Fig. 16, **30**) arising on the dorsal portion of the pleuron. Both are attached on the common depressor apodeme of the ventral base of the trochanter.

b. Pterothoracic Musculature

1) Dorsal Muscles

Each segment has three dorsal muscles on each side: A very thick longitudinal median internal muscle (Fig. 16, **31**; **62**) stretched between both ends of the tergum near the dorsal median line, a very slender longitudinal median external muscle (Fig. 16, **32**; **63**) arising on the middle of the median region of the tergum and inserted into the inside of the internal muscle, and a very thick oblique lateral dorsal muscle (Fig. 16, **33**; **64**) originated on the middle of the median region of the tergum outside the median external dorsal muscle and attached on the posterior end of the tergum outside the median internal dorsal.

2) Ventral Muscles

The mesothorax has three pairs of ventral muscles, longitudinal ventrals (Fig. 16, **34**), furco-spinal oblique ventrals (Fig. 16, **35**) and spino-furcal oblique ventrals (Fig. 16, **36**). These are very similar to

those of the mesothorax in the Isoptera. The metathorax has two pairs of ventral muscles, longitudinal ventrals (Fig. 16, **65**) and spinofurcal oblique ventrals (Fig. 16, **66**). Both muscles are very similar to those in the mesothorax.

3) **Tergo-Sternal Muscles**

Each segment has two anterior tergo-sternal muscles and a posterior tergo-sternal muscle on each side. The first anterior tergosternal muscle (Fig. 16, **37**) in the mesothorax is attached dorsally on the anterior side of the prealar sclerite, and ventrally on the intersegmental membrane behind the profurcal arm. That in the metathorax (Fig. 16, **67**) is attached dorsally on the anterior side of the prealar sclerite and ventrally on the antero-lateral corner of the sternum. The second anterior tergo-sternal muscle (Fig. 16, **38** ; **68**) is very thick, arising on the anterior portion of the tergum behind the anterior end of the median internal dorsal muscle, and attached ventrally on the sternum forward the furcal arm. The posterior tergo-sternal muscle (Fig. 16, **39** ; **69**) is similar to that in the prothorax.

4) **Tergo-Pleural Muscles**

Four tergo-pleural muscles are observed on each side, two ordinary tergo-pleural muscles, a pleuro-axillary muscle and a pleurosubalar muscle. The first ordinary tergo-pleural muscle (Fig. 16, **40** ; **70**) arises on the antero-lateral corner of the tergum and is inserted into the anterior margin of the basalare; the second (Fig. 16, **41, 71**) is a broad vertical muscle arising on the lateral region of the tergum and inserted into the pleural ridge. The pleuro-axillary muscle (Fig. 16, **42** ; **72**) is fan-shaped, arising on the anterior portion of the episternum immediately behind the basalare, and inserted into the third axillary sclerite. The pleuro-subalar muscle (Fig. 16, **43** ; **73**) is very small, attached dorsally on the posterior portion of the subalare and ventrally on the dorsal margin of the epimeron.

5) **Sterno-Pleural Muscles**

Four sterno-pleural muscles are found on each side: An ordinary sterno-pleural muscle, two sterno-basalar muscles, a furco-entopleural muscle. The ordinary sterno-pleural muscle (Fig. 16, **44** ; **74**) is slender,

arising on the posterior end of the sternum and inserted into the middle of the ventral region of the episternum. The first sterno-basalar muscle (Fig. 16, **45**; **75**) is fan-shaped, very thick, originating on the antero-lateral region of the sternum before the second anterior tergo-sternal muscle by a wide base. The second (Fig. 16, **46**; **76**) is fan-shaped, thicker than the first, and arising on the sternum lateral to the second anterior tergo-sternal muscle by a broad base. Both are inserted into the basalare. The furco-entopleural muscle (Fig. 16, **47**; **77**) connects the apex of the furcal arm with the middle portion of the pleural ridge.

6) Caxal Muscles and Coxal Wing Muscles

On each side there are eight coxal muscles and two coxal wing muscle: A tergal promotor, a sternal promotor, two tergal remotors, two sternal remotors, a sternal adductor, and a pleural abductor; a coxo-subalar muscle and a coxo-basalar muscle.

The tergal promotor (Fig. 16, **48**; **78**) is thick, arising on a position somewhat anterior to the middle of the dorso-lateral region of the tergum, and attached on the apical portion of the trochantin. The sternal promotor (Fig. 16, **49**; **79**) is fan-shaped, originating on the sternum behind the furcal arm, and attached on the anterior basal rim of the coxa at the coxo-trochantinal joint. The first tergal remotor (Fig. 16, **50**; **80**) is an inner thick bundle arising on the tergum immediately behind the tergal promotor, the second (Fig. 16, **51**; **81**) is an outer thinner bundle arising on the middle of the lateral region of the alinotum or anterior wing bearing plate of the tergum. Both are attached on the common remotor apodeme of the postero-lateral basal rim of the coxa. The coxo-basalar muscle (Fig. 16, **52**; **82**) is similar to that in the already mentioned insects. The first sternal remotor (Fig. 16, **53**; **83**) is fan-shaped, arising on the basal portion of the furcal arm and inserted into the common remotor apodeme on the postero-lateral basal rim of the coxa. The second (Fig. 16, **54**; **84**) is slender, and connects the apex of the furcal arm with the postero-lateral basal rim of the coxa. The sternal adductor (Fig. 16, **55**; **85**) is very similar to that in the prothorax. The pleural abductor (Fig. 16, **56**; **86**) is slender, takes its origin on the central portion of the

TABLE VI

Embioptera
Oligotomidae
Oligotoma saundersi (Fig. 16)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	3 (1) (2) (3)
Lateral dorsals.	1 (4)
Anterior dorsals.	1 (5)
Ventral Muscles.	
Internal ventrals.	2 (6) (7)
External ventrals.	1 (8)
Ventral Transverse Müscles.	2 (9) (10)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2(11) (12)
Anterior internal tergo-sternals.	1(13)
Anterior external tergo-sternals.	3(14) (15) (16)
Posterior tergo-sternals.	2(17) (18)
Tergo-Pleural Muscles.	
Ordinary tergo-pleurals.	1(19)
Coxal Muscles.	
Tergal promotor.	2(20) (21)
Ordinary sternal promotor.	1(22)
Tergal remotor.	2(23) (24)
Ordinary sternal remotor.	1(25)
Sternal adductor.	1(26)
Tergal abductor.	1(27)
Pleural abductor.	1(28)
Trochanteral Muscles Arising on the Thorax.	
Tergal depressor.	1(29)
Pleural depressor.	1(30)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	2(31) (32)	2(62) (63)
Lateral dorsals.	1(33)	1(64)
Ventral Muscles.		
Longitudinal ventrals.	1(34)	1(65)
Furco-spinal ventrals.	1(35)	—
Spino-furcal ventrals.	1(36)	1(66)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	2(37) (38)	2(67) (68)
Posterior tergo-sternals.	1(39)	1(69)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	2(40) (41)	2(70) (71)
Pleuro-axillary muscles.	1(42)	1(72)
Pleuro-subalar muscles.	1(43)	1(73)
Sterno-Pleural Muscles.		
Ordinary sterno-pleurals.	2(44) (45)	1(74)
Sterno-basalar muscles.	1(46)	2(75) (76)
Furco-entopleural muscles.	1(47)	1(77)
Coxal Muscles, and Coxal Wing Muscles.		
Tergal promotor of the coxa.	1(48)	1(78)
Ordinary sternal promotor of the coxa.	1(49)	1(79)
Tergal remotor of the coxa.	2(50) (51)	2(80) (81)
Coxo-subalar muscles.	1(52)	1(82)
Ordinary sternal remotor of the coxa.	2(53) (54)	2(83) (84)
Sternal adductor of the coxa.	1(55)	1(85)
Pleural abductor of the coxa.	1(56)	1(86)
Coxo-basalar muscles.	1(57)	1(87)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressor of the trochanter.	1(58)	1(88)
Trochantero-basalar muscle.	1(59)	1(89)
Sternal depressor of the trochanter.	1(60)	1(90)
Muscles of the Spiracle.	1(61)	1(91)

b) Abdominal Musculature

	I Segment	II–VI Segments
Dorsal Muscles.	2 (92)	2(102)
	(93)	(103)
Dorsal Transverse Muscles.	—	1(104)
Ventral Muscles.	2 (94)	3(105)
	(95)	(106)
		(107)
Tergo-Sternal Muscles.	4 (96)	7(108)
	(97)	(109)
	(98)	(110)
	(99)	(111)
		(112)
		(113)
		(114)
Tergo-Pleural Muscles.	1(100)	2(115)
		(116)
Occlusor of the Spiracle.	1(101)	1(117)

episternum and its insertion into the antero-lateral basal rim of the coxa. The coxo-basalar muscle (Fig. 16, **57**; **87**) is thick, stretched between the anterior coxal basal rim and the dorsal portion of the basalare.

7) Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles

Each side of the segment has a tergal (Fig. 16, **58**; **88**) and a sternal depressor (Fig. 16, **60**; **90**) of the trochanter, and a trochantero-basalar muscle (Fig. 16, **58**; **89**). These are similar to those in the Isoptera.

8) Muscles of the Spiracles

Each thoracic spiracle has an occlusor. The muscle in the first thoracic spiracle is very small, connecting the posterior end of the peritreme with the posterior end of the spiracle. That in the second thoracic spiracle is long, vertical, arising on the antero-lateral corner of the sternum and inserted into the ventral end of the spiracle (Fig. 16, **61**; **91**).

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 16 and Table VI.

6. PSOCOPTERA

Psocidae. *Psocus tokyoensis* ENDERLEIN (Fig. 17)

a. Prothoracic Musculature

1) Dorsal Muscles

There are two dorsal muscles on each side, a median and an anterior. The median dorsal (Fig. 17, **1**) is longitudinal, arising on the anterior portion of the tergum and inserted into the first phragma, near the dorsal median line. The anterior dorsal muscle (Fig. 17, **2**) is oblique, attached anteriorly on the dorso-lateral portion of the posterior end of the head and posteriorly on the median portion of the tergum before the anterior end of the median muscle.

2) Ventral Muscles

The ventral muscles are one-paired, longitudinal, thick, arising on the ventro-lateral portions of the posterior end of the head and inserted into the furcal arms (Fig. 17, **3**).

3) Ventral Transverse Muscles

A pair of ventral transverse muscles very similar to those of the prothorax in the Orthoptera are found (Fig. 17, **4**).

4) Tergo-Sternal Muscles

Four tergo-sternal muscles are found on each side: An anterior intersegmental tergo-sternal muscle (Fig. 17, **5**) attached dorsally on the posterior end of the head near the dorsal median line, and ventrally on the posterior half of the ventro-lateral cervical sclerite; two anterior internal tergo-sternals, one (Fig. 17, **6**) attached dorsally on the middle of the dorso-lateral membrane of the cervical region and ventrally on the anterior portion of the ventro-lateral cervical sclerite, the other (Fig. 17, **7**) arising on the antero-median portion of the tergum lateral to the anterior dorsal muscle and attached on the inner portion of the ventro-lateral cervical sclerite; a posterior tergo-sternal muscle (Fig. 17, **8**) stretched between the furcal arm and the antero-lateral corner of the mesotergum.

5) **Tergo-Pleural Muscles**

The tergo-pleural muscles are two-paired. The anterior pair (Fig. 17, **9**) are intersegmental, arising on the dorso-lateral portions of the posterior end of the head, and inserted into the pleural ridges. The posterior pair (Fig. 17, **10**) are vertical, fan-shaped, originating on the anterior margins of the dorso-lateral regions of the tergum, and attached on the pleural ridges by wide bases.

6) **Sterno-Pleural Muscles**

A pair of furco-entopleural muscles stretched between the pleural ridges and the furcal arms are found (Fig. 17, **11**).

7) **Coxal Muscles**

Five coxal muscles arising on the thorax are found on each side: A tergal promotor (Fig. 17, **12**) arising on the antero-median portion of the tergum, and inserted into the anterior basal rim of the coxa; a cervical sternal promotor (Fig. 17, **13**) arising on the inner margin of the ventro-lateral cervical sclerite and inserted into the anterior basal wall of the coxa of the opposite side; a very thick tergal remotor (Fig. 17, **14**) arising on the dorso-lateral region of the tergum and attached on the postero-lateral basal rim of the coxa; a small sternal remotor (Fig. 17, **15**) originated on the apex of the furcal arm and inserted into the postero-lateral basal rim of the coxa around the posterior side of the tergal remotor; a short fan-shaped pleural abductor (Fig. 17, **16**) arising on the episternum forward the middle of the pleural ridge and inserted into the antero-lateral basal rim of the coxa.

8) **Trochanteral Muscles Arising on the Thorax**

A thick muscle arising on the median portion of the tergum and attached on the common depressor apodeme of the trochanter is found on each side (Fig. 17, **17**).

b. Pterothoracic Musculature

1) **Dorsal Muscles**

The meso- and metathorax have two dorsal muscles on each side, a median and a lateral. The median muscle (Fig. 17, **18**; **43**)

is very thick, especially remarkable in that of the mesothorax, longitudinal, stretched between both ends of the tergum near the dorsal median line. The lateral muscle (Fig. 17, **19**; **44**) is very thick, oblique, arising on the median region of the scutum, and attached on the lateral portion of the posterior end of the tergum.

2) **Ventral Muscles**

The mesothorax has a longitudinal ventral muscle (Fig. 17, **20**) and a spino-furcal ventral muscle (Fig. 17, **21**), and the metathorax has only a longitudinal ventral muscle (Fig. 17, **45**), on each side; these are very similar to those in the Embioptera, Isoptera, Plecoptera, etc.

3) **Tergo-Sternal Muscles**

A posterior tergo-sternal muscle (Fig. 17, **22**; **46**) attached dorsally on the lateral portion of the intersegmental ridge at the posterior end of the tergum and ventrally on the apex of the furcal arm is found on each side.

4) **Tergo-Pleural Muscles**

The mesothorax has five ordinary tergo-pleural muscles (Fig. 1, **23, 24, 25, 26, 27**) and a pleuro-axillary muscle (Fig. 17, **28**) on each side: The first ordinary tergo-pleural muscle is small, arising on the anterior end of the dorso-lateral region of the tergum, and inserted into the antero-dorsal portion of the episternum; the second is a small muscle arising on the lateral margin of the scutum before the wing base and inserten into the antero-dorsal portion of the episternum; the third is very small, attached dorsally on the prealar sclerite detached from the tergum and ventrally on the pleural ridge beneath the pleural wing process; the fourth is very small, arising on the anterior notal wing process and inserted into the pleural ridge as the third, and the fifth is longer than the fourth, attached dorsally on the anterior notal wing grocess as the fourth and ventrally on the pleural ridge beneath the fourth muscle. The pleuro-axillary muscle is fan-shaped, arising on the middle portion of the pleural ridge by a wide base and inserted into the third axillary of the wing base. The metathorax has four ordinary tergo-pleural muscles and a pleuro-

axillary muscle (Fig, 17, **47, 48, 49, 50** and **51**); these correspond to the mesothoracic muscles (Fig. 17, **23, 25, 26, 27** and **28**) respectively.

5) Pleural Muscles

The metathorax has a muscle (Fig. 17, **52**) attached dorsally on the antero-ventral corner of the episternum, and ventrally on the lateral intersegmental ridge before the lateral portion of the trochantin, on each side.

6) Coxal Muscles and Coxal Wing Muscles

The muscles are found on each side of the mesothorax as follows: Seven coxal muscles—tergal promotor (Fig. 17, **29**) arising on the anterior portion of the dorso-lateral region of the tergum by a wide base and attached on the trochantin; a long slender anterior spinal promotor (Fig. 17, **30**) arising on the spina at the posterior end of the prosternum, and inserted into the anterior basal wall of the coxa; two tergal remotors, an internal muscle (Fig. 17, **31**) arising on the antero-median portion of the tergum and inserted into the common remotor apodeme on the posterior basal rim of the coxa, and an external muscle (Fig. 17, **32**) arising on the lateral portion of the tergum between the anterior and posterior notal wing processes and inserted into the common remotor apodeme as the first; a sternal remotor (Fig. 17, **35**) originated on the outside of the base of the furcal arm and inserted into the postero-lateral basal rim of the coxa; two pleural abductors, a fan-shaped muscle (Fig. 17, **36**) arising on the episternum along the pleural ridge and inserted into the antero-lateral basal rim of the coxa, a muscle (Fig, 17. **37**) arising on the antero-ventral portion of the episternum and inserted into the basal rim of the coxa inside the first. Three coxal wing muscles—two coxo-subalar muscles, one (Fig. 17, **33**) attached dorsally on the subalare and ventrally on the posterior basal rim of the coxa inside the tergal remotors, the other (Fig. 17, **34**) attached dorsally on the subalare and ventrally on the remotor apodeme as the tergal remotor; a coxo-basalar muscle (Fig. 17, **38**) is long, thick, arising on the dorsal portion of the episternum and attached on the basal rim of the coxa inside the second.

TABLE VII.

Psocoptera
Psocidae
Psocus tokyoensis (Fig. 17)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; " — " shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1 (1)
Anterior dorsals.	1 (2)
Ventral Muscles.	
Long longitudinal ventrals.	1 (3)
Ventral Transverse Muscles.	1 (4)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	1 (5)
Anterior internal tergo-sternals.	2 (6) (7)
Posterior tergo-sternals.	1 (8)
Tergo-Pleural Muscles.	
Anterior tergo-pleurals.	1 (9)
Ordinary tergo-pleurals.	1 (10)
Sterno-Pleural Muscles.	
Furco-entopleural muscles.	1 (11)
Coxal Muscles.	
Tergal promotors.	1 (12)
Anterior (cervical) sternal promotors.	1 (13)
Tergal remotors.	1 (14)
Ordinary sternal remotors.	1 (15)
Pleural abductors.	1 (16)
Trochanteral Muscles Arising on the Thorax.	
Tergal depressors.	1 (17)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	1 (18)	1 (43)
Lateral dorsals.	1 (19)	1 (44)
Ventral Muscles.		
Longitudinal ventrals.	1 (20)	1 (45)
Spino-furcal ventrals.	1 (21)	—
Tergo-Sternal Muscles.		
Posterior tergo-sternals.	1 (22)	1 (46)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	5 (23) (24) (25) (26) (27)	4 (47) (48) (49) (50)
Pleuro-axillary muscles.	1 (28)	1 (51)
Pleural Muscles.	—	1 (52)
Coxal Muscles and Coxal Wing Muscles.		
Tergal promotors of the coxa.	1 (29)	—
Anterior spinal promotors of the coxa.	1 (30)	—
Anterior furcal promotors of the coxa.	—	1 (53)
Tergal remotors of the coxa.	2 (31) (32)	2 (54) (55)
Coxo-subalar muscles.	2 (33) (34)	1 (56)
Ordinary sternal remotors of the coxa.	1 (35)	1 (57)
Pleural abductors of the coxa.	2 (36) (37)	2 (58) (59)
Coxo basalar muscles.	1 (38)	1 (60)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1 (39)	1 (61)
Trochantero-basalar muscles.	1 (40)	1 (62)
Sternal depressors of the trochanter.	1 (41)	1 (63)
Muscles of the Spiracle.	1 (42)	2 (64) (65)

b) Abdominal Musculature

	I Segment	II Segment	III–VI Segments
Dorsal Muscles.	2(66) (67)	3(71) (72) (73)	3(78) (79) (80)
Dorsal Transverse Muscles.	—	—	1(81)
Ventral Muscles.	2(68) (69)	1(74)	1(82)
Tergo-Sternal Muscles.	—	2(75) (76)	3(83) (84) (85)
Occlusor of the Spiracle.	1(70)	1(77)	1(86)

Eight muscles attached on the coxa are observed in the metathorax as follows: An anterior sternal promotor (Fig. 17, **53**) arising on the mesothoracic furcal arm and inserted into the anterior basal wall of the coxa; an internal and an external tergal remotor (Fig. 17, **54**, **55**), sternal remotor (Fig. 17, **57**), two pleural abductors (Fig. 17, **58**, **59**), a coxo-subalar muscle (Fig. 17, **56**) and a coxo-basalar muscle (Fig. 17, **65**) corresponding to the mesothorax (Fig. 17, **31**, **32**, **35**, **36**, **37**, **34**, **38**) respectively.

7) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

Each side of the pterothoracic segment has a tergal (Fig. 17, **39**; **61**) and a sternal depressor (Fig. 17, **41**; **63**) of the trochanter and a trochantero-basalar muscle (Fig. 17, **40**; **62**); these are very similar to those in the Isoptera.

8) Muscles of the Spiracles

The first thoracic spiracle has an occlusor (Fig. 17, **42**) arising on the intersegmental sclerite before the spiracle and attached on the ventral side of the spiracle. The second thoracic spiracle has two occlusors (Fig. 17, **64**, **65**) arising on the posterior portion of the mesepimeron and inserted into the under side of the spiracle.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 17 and Table VII.

7. EPHEMEROPTERA

Ecdyonuridae. *Ecdyonurus hyalinus* ULMER (Fig. 18)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax of the may-fly has three dorsal muscles: A median longitudinal muscle (Fig. 18, **1**) attached anteriorly on the posterior end of the head and posteriorly on the anterior end of the mesotergum near the dorsal median line; a lateral muscle (Fig. 18, **2**) arising on the dorso-lateral region of the tergum immediately behind the faint transverse tergal ridge and inserted into the anterior end of the mesotergum lateral to the median muscle; an anterior muscle (Fig. 18, **3**) attached anteriorly on the porterior end of the head as the anterior attachment of the median muscle and posteriorly on the middle of the median region of the tergum.

2) Ventral Muscles

The ventral muscles are one-paired, arising on the ventral posterior end of the head behind the posterior tentorial pits, and inserted into the furcal arms (Fig. 18, **4**).

3) Tergo-Sternal Muscles

Four tergo-sternal muscles are found on each side: An anterior intersegmental tergo-sternal muscle (Fig. 18, **5**) arising on the dorso-lateral portion of the posterior end of the head, and inserted into the posterior portion of the ventro-lateral cervical sclerite; two anterior internal tergo-sternal muscles, the first (Fig. 18, **6**) is thick, arisen on the dorso-lateral region of the tergum immediately forward the faint transverse tergal ridge, the second (Fig. 18, **7**) is shorter than the first, arising on the anterior end of the dorso-lateral region of the tergum, and both are attached on the anterior portion of the ventro-lateral cervical sclerite; a slender posterior tergo-sternal muscle (Fig, 18, **8**) arising on the antero-lateral portion of the mesotergum and attached on tne profurcal arm.

4) **Tergo-Pleural Muscles**

An anterior longitudinal tergo-pleural muscle (Fig. 18, **9**) arising on the dorso-lateral portion of the posterior end of the head inserted into the dorsal portion of the pleuron, and a vertical small tergo-pleural muscle (Fig. 18, **10**) connecting the middle of the lateral region of the tergum with the dorsal margin of the pleuron, are found on each side.

5) **Coxal Muscles**

Eight coxal muscles are found on eace side: A tergal promotor, three tergal remotors, a sternal remotor, two tergal abductors and a pleural abductor.

The tergal promotor (Fig. 18, **11**) arises on the latero-anterior portion of the tergum and attaches on the anterior basal rim of the coxa lateral to the coxo-trochantinal joint. The first tergal remotor (Fig. 18, **12**) is an anterior internal muscle arising on the middle of the laterl region of the tergum, the second (Fig. 18, **13**) is a posterior internal muscle arising on the posterior of the lateral region of the tergum, the third (Fig. 18, **14**) is an external muscle arising on the posterior portion of the tergum lateral to the second, all these are inserted into the posterior basal rim of the coxa. The sternal remotor (Fig. 18, **15**) connects the furcal arm with the posterior basal rim of the coxa. The first tergal abductor (Fig. 18, **16**) is an anterior bundle arising on the middle of the dorso-lateral region of the tergum, the second (Fig. 18, **17**) is a posterior bundle arising on the posterior portion of the dorso-lateral region of the tergum. Both are inserted into the antero-lateral basal rim of the coxa. The pleural abductor (Fig. 18, **18**) is a short muscle arising on the antero-dorsal portion of the pleuron and inserted into the antero-lateral basal rim of the coxa as the tergal abductors.

6) **Trochanteral Muscles**

The trochanteral muscles arising on the prothorax are one-paired, very thick, take their origins on the dorsal portions of the pleura and attach on the common depressor apodemes on the ventral bases of the trochanters. (Fig. 18, **19**).

b. Pterothoracic Musculature

1) Dorsal Muscles

The mesothorax has two dorsal muscles on each side: A very thick median longitudinal muscle (Fig. 18, **20**) arising on the anterior half of the median region of the alinotum and inserted into the second phragma; a thick lateral oblique muscle (Fig. 18, **21**) arising on the dorso-lateral portion of the posterior region of the alinotum and inserted into the lateral portion of the postnotum. The metathorax has only a very thick median longitudinal muscle (Fig. 18, **47**) attached anteriorly on the second phragma and posteriorly on the posterior end of the tergum near the median line, on each side.

2) Ventral Muscles

Each segment has a pair of longitudinal ventral muscles (Fig. 18, **22**; **48**) stretched between the furcal arms of itself and the furcal arms of the preceding segment.

3) Ventral Transverse Murcles

In each segment is found a posterior slender ventral transverse muscle (Fig. 18, **23**;**49**) stretched between the furcal arms of both sides.

4) Tergo-Sternal Muscles

The mesothorax is provided with five tergo-sternal muscles on each side: Two anterior tergo-sternal muscles, the first (Fig. 18, **24**) is slender, arising on the antero-lateral portion of the tergum and inserted into the antero-lateral corner of the sternum, the second (Fig. 18, **25**) is a very thick muscle arising on the dorso-lateral region of the tergum lateral to the anterior portion of the median dorsal muscle, and inserted into the ventro-lateral region of the segment before the furcal arm; two sterno-subalar muscles, the first (Fig. 18, **26**) is very thick, takes its origin on the posterior sternal region by a broad base, the second (Fig. 18, **27**) is slender, arising on the furcal arm, both are inserted into the posterior apodeme of the subalare; a slender sterno-axillary muscle (Fig. 18, **28**) arising on the furcal arm and inserted into the first axillary.

The metathorax has four tergo-sternal muscles on each side: Two anterior tergo-sternal muscles (Fig. 18, **50**, **51**), the first is very small, arising on the lateral portion of the second phragma and inserted into the lateral wing of the sternum, the second is similar to the second anterior tergo-sternal muscle of the mesothorax, but more slender; a slender sterno-subalar muscle (Fig. 18, **52**) arising on the lateral margin of the posterior sternal region fused to the first abdominal sternum, and inserted into the subalar membrane, probably corresponding to the first sterno-subalar muscle (Fig. 18, **26**) of the mesothorax; a sterno-axillary muscle (Fig. 18, **53**) very similar to that (Fig, 18, **28**) in the mesothorax.

5) Tergo-Pleural Muscles

Two ordinary tergo-pleural muscles and two pleuro-axillary muscles are found on each side. The first ordinary tergo-pleural muscle (Fig. 18, **29**; **54**) arises on the lateral portion of the tergum above the basalare and is inserted into the dorsal portion of the trochantin. The second ordinary tergo-pleural muscle (Fig. 18, **30**; **55**) is very small, attached dorsally on the prealar sclerite and ventrally on the dorsal portion of the pleuron beneath the pleural wing process. The first pleuro-axillary muscle (Fig. 18, **31**; **56**) is very slender, arising on the pleural coxal process and inserted into the anterior portion of the first axillary sclerite. The second pleuro-axillary muscle (Fig. 18, **32**; **57**) is very small, arising on the pleural wing process and inserted into the third axillary sclerite.

6) Sterno-Pleural Muscles

The mesothorax has two sterno-basalar muscles aud a furco-entopleural muscle, and the metathorax has only a furco-entopleural muscle, on each side. The first sterno-basalar muscle (Fig. 18, **33**) of the mesothorax is very slender, arising on the anterior margin of the basalare, the second (Fig. 18, **34**) is slender, arising on the ventral end of the basalare, both are attached on the antero-lateral corner of the sternum. The furco-entopleural muscle (Fig. 18, **35**; **58**) in both segments is very slender, stretched between the furcal arm and the pleural coxal process.

7) Coxal Muscles and Coxal Wing Muscles

Eight muscles arising on the thorax are attached on each mesothoracic coxa: A tergal promotor (Fig. 18, **36**), two sternal promotors (Fig. 18, **37**, **38**), two tergal remotors (Fig. 18. **39, 40**), a sternal remotor (Fig. 18, **42**) and a pleural abductor (Fig. 18, **43**) of the coxa; a coxo-subalar muscle (Fig. 18, **41**). The tergal promotor is very thick, arising on the middle of the lateral region of the tergum by a broad base, and inserted into the anterior basal rim of the coxa. The first sternal promotor arises on the furcal arm and attaches on the anterior basal wall of the coxa, the second is very small, arising on the furcal arm and inserted into the antero-median basal rim of the coxa at the coxo-trochantinal joint. The first tergal remotor is an internal thick muscle arising on the middle of the dorso-lateral region of the tergum behind the tergal promotor by a wide base, the second is an external slender muscle arising on the tergum at the latero-posterior side of the first, both are inserted into the posterior basal rim of the coxa. The coxo-subalar muscle is slender, attached dorsally on the anterior portion of the subalare, and ventrally on the postero-lateral basal rim of the coxa. The sternal remotor arises on the furcal arm by a wide base, and attaches on the postero-lateral basal rim of the coxa. The pleural abductor arises on the pleuron at the antero-lateral side of the coxal base and attaches on the antero-lateral basal rim of the coxa.

The metathorax has seven coxal muscles on each side, a tergal promotor (Fig. 18, **59**), two sternal promotors (Fig. 18, **60, 61**), two tergal remotors (Fig. 18, **62, 63**), a sternal remotor (Fig. 18, **64**) and a pleural abductor (Fig. 18, **65**). These are very similar to those in the mesothorax (Fig. 18, **36, 37, 38, 39, 40, 42, 43**) respectively. The metathorax lacks the muscle corresponding to the coxo-subalar muscle in the mesothorax.

8) Trochanteral Muscles Arising on the Thorax

The trochanter has two muscles arising on the thorax: A thick tergal depressor (Fig. 18, **44**; **66**) arising on the middle of the lateral region of the tergum inside the anterior notal wing process,

and a thick pleural depressor (Fig. 18, 45; 67) arising on the pleuron at the antero-lateral side of the coxal base, both are inserted into the common depressor apodeme of the trochanter as those in the other insects.

9) Muscles of the Spiracles

Each thoracic spiracle has a very small occlusor (Fig. 18, 46; 68). The occlusor in the first thoracic spiracle arises on the subspiraculare, that in the second thoracic spiracle on the intersegmental

TABLE VIII.

Ephemeroptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figure; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Ecdyonuridae. *Ecdyonurus hyalinus* (Fig. 18)	Ephemeridae. *Hexagenia recurvata* (KNOX, 1935)
Dorsal Muscles.		
Median dorsals.	1 (1)	2 (IDlm 2) (IDlm 1)
Lateral dorsals.	1 (2)	1 (IDm)
Anterior dorsals.	1 (3)	—
Ventral Muscles.		
Long longitudinal ventrals.	1 (4)	1 (I Vlm 1)
Short longitudinal (cervico-furcal) ventrals.	—	1 (I Vlm 2)
Tergo-Sternal Muscles.		
Anterior intersegmental tergo-sternals.	1 (5)	1 (ISm 4)
Anterior internal tergo-sternals,	2 (6) (7)	5 (Cv 1) (Cv 2) (Cv 3) (Cv 4) (Cv 5)
Posterior tergo-sternrls.	1 (8)	
Tergo-Pleural Muscles.		
Anterior tergo-pleurals.	1 (9)	1 (IPm 3)
Ordinary tergo-pleurals.	1 (10)	—
Coxal Muscles.		
Tergal promotors.	1 (11)	1 (IDvm 2)
Tergal remotors.	3 (12) (13) (14)	3 (IDvm 4) (IDvm 3) (IDvm 5)
Ordinary sternal remotors.	1 (15)	3 (ISm 1 (ISm 2) (ISm 3)
Tergal abductors.	2 (16) (17)	1 (IDvm 1)
Pleural abductors.	1 (18)	1 (IPm 1)
Trochanteral Muscles Arising on the Thorax.		
Pleurnl depressors.	1 (19)	1 (IPm 2)

b) Mesothoracic Musculature

	Ecdyonuridae. *Ecdyonurus hyalinus* (Fig. 18)	Ephemeridae. *Hexagenia recurvata* (KNOX, 1935)	Baetidae. *Centroptilum. luteolum* (DÜRKEN, 1907)	Baetidae. *Ephemerella ignita* (DÜRKEN, 1907)
Dorsal Muscles.				
Median dorsals.	1(20)	1(IIDlm)	1(IIdlm)	1(IIdlm)
Lateral dorsals.	1(21)	1(IIDm)	1(IIdm)	1(IIdm)
Ventral Muscles.				
Longitudinal ventrals.	1(22)	1(IIVlm)	1(IIvlm)	1(A part of IIivlm)
Ventral Transverse Muscles.				
Posteriors.	1(23)	1(IIsm 2)	1(IIsm 5)	1(IIsm 5)
Tergo-Sternal Muscles.				
Anterior tergo-sternals.	2(24) (25)	1(IIDvm 1)	1(IIdvm 1)	1(IIdvm 1)
Sterno-subalar muscles.	2(26) (27)	2(IIPm 7) (IIPm 8)	2(IIpm 5) (IIpm 6)	2(IIpm 6) (IIpm 5)
Sterno-axillary muscles.	1(28)	1(IIPm10)	1(IIdvm 6)	1(IIdvm 5)
Tergo-Pleural Muscles.				
Ordinary tergo-pleurals.	2(29) (30)	2(IIPm11) (IIPm 5)	3(IIpm 7) (IIpm10) (IIpm 9)	3(IIpm 7) (IIpm 9) (IIpm10)
Pleuro-axillary muscles.	2(31) (32)	1(IIPm 6)	1(IIpm 8)	1(IIpm 8)
Pleuro-subalar muscles.	—	—	—	1(IIpm11)
Sterno-Pleural Muscles.				
Sterno-basalar muscles.	2(33) (34)	2(IIPm 1) (IIPm 2)		
Furco-entopleural muscles.	1(35)	—		
Coxal Muscles and Coxal Wing Muscles.				
Tergal promotors of the coxa.	1(36)	1(IIDvm 2)	1(IIdvm 2)	1(IIdvm 2)
Ordinary sternal promotors of the coxa.	2(37) (38)	1(IISm 1)	2(IIsm 1) (IIsm 2)	2(IIsm 1) (IIsm 3)
Tergal remotors of the coxa.	2(39) (40)	3(IIDvm 3) (IIDvm 4) (IIDvm 5)	2(IIdvm 3) (IIdvm 4)	1(IIdvm 3)
Coxo-subalar muscles.	1(41)	1(IIPm 9)	1(IIpm 2)	1(IIpm 2)
Ordinary sternal remotors of the coxa.	1(42)	—	1(IIsm 3)	1(IIsm 2)
Pleural abductors of the coxa.	1(43)	1(IIPm12)	1(IIpm 1)	1(IIpm 1)
Coxo-basalar muscles.	—	1(IIPm 4)	—	1(IIpm 4)
Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.				
Tergal depressors of the trochanter.	1(44)	1(IIDvm 6)	1(IIdvm 5)	1(IIdvm 4)
Pleural depressors of the trochanter.	1(45)	1(IIPm13)	1(IIpm 3)	1(IIpm 3)
Trochantero-basalar muscles.	—	1(IIPm 3)	1(IIpm 4)	—
Sternal depressors of the trochanter.	—	—	1(IIsm 4)	1(IIsm 4)
Muscles of the Spiracle.	1(46)			

c) Metathoracic Musculature

	Ecdyonuridae. *Ecdyonurus hyalinus* (Fig. 18)	Ephemeridae. *Hexagenia recurvata* (KNOX, 1935)	Baetidae. *Centroptilum luteolum* (DÜRKEN, 1907)	Baetidae. *Ephemerella ignita* (DÜRKEN, 1907)
Dorsal Muscles.				
Median dorsals.	1(47)	1(IIIDlm)	1(IIIdlm)	1(IIIdlm)
Lateral dorsals.	—	—	—	—
Common dorsal muscles of metathorax and I abdominal segment.	—	—	1(IIIidlm)	—
Ventral Muscles.				
Longitudinal ventrals.	1(48)	—	—	—
Posterior ventrals.	—	—	1(IIIvlm)	3(IIIvlm 1, IIIvlm 2; a part of IIIivlm)
Common ventrals of meso-, metathorax and I abdominal segment.	—	—	—	1(A part of IIivlm)
Ventral Transverse Muscles.				
Posterior.	1(49)	1(IIISm3)	1(IIIsm4)	1(IIIsm4)
Tergo-Sternal Muscles.				
Anterior tergo-sternals.	2(50) (51)	1(IIIDvm1)	1(IIIdvm1)	1(IIIdvm1)
Sterno-subalar mucles.	1(52)	—	—	1(IIIpm4)
Sterno-axillary mucles.	1(53)	1(IIIPm4)	—	—
Posterior tergo-sternals.	—	1(IIIDvm4)	2(IIIdvm5) (IIIidvm)	2(IIIdvm7) (IIIidvm)
Tergo-Pleural Muscles.				
Ordinary tergo-pleurals.	2(54) (55)	3(IIIPm 1) (IIIPm 3) (IIIPm 11)		2(IIIpm5) (IIIpm6)
Pleuro-axillary muscles.	2(56) (57)	1(IIIPm 6)	1(IIIpm5)	1(IIIpm7)
Sterno-Pleural Muscles.				
Furco-entopleurals.	1(58)	1(IIISm1)	—	1(IIIsm2)
Coxal Muscles and Coxal Wing Muscles.				
Tergal promotors of the coxa.	1(59)	1(IIIDvm2)	1(IIIdvm2)	1(IIIdvm2)
Ordinary sternal promotors of the coxa.	2(60) (61)	1(IIISm4)	2(IIIsm1) (IIIsm2)	1(IIIsm1)
Tergal remotors of the coxa.	2(62) (63)	1(IIIDvm3)	1(IIIdvm3)	2(IIIdvm4) (IIIdvm5)
Coxo-subalar muscles.	—	1(IIIPm5)	1(pm3)	1(IIIpm2)
Ordinary sternal remotors of the coxa.	1(64)	1(IIISm2)	—	—
Tergal abductors of the coxa.	—	—	—	1(IIIdvm3)
Pleural abductors of the coxa.	1(65)	1(IIIPm8)	1(IIIpm1)	1(IIIpm1)
Trochanteral Muscles Arising on the Thorax.				
Tergal depressors.	1(66)	1(IIIDvm5)	1(IIIdvm4)	1(IIIdvm6)
Pleural depressors.	1(67)	1(IIIPm7)	1(IIIpm4)	1(IIIpm3)
Sternal depressors.	—	—	1(IIIsm3)	1(IIIsm3)
Muscles of the Spiracle.	1(68)	1(IIIPm9)	1(IIpm11)	2(IIpm12) (IIpm13)

d) Abdominal Musculature of *Ecdyonurus hyalinus*

	I Segment	II-VI Segments
Dorsal Muscles.	2(69) (70)	2(74) (75)
Ventral Muscles.	1(71)	1(76)
Tergo-Sternal Muscles.	2(72) (73)	3(77) (78) (79)

ridge at the antero-lateral corner of the sternum, and both take each the insertion into the under side of the spiracle.

The thoracic muscles are tabulated above, including those of some other species observed by other authors.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 18 and Table VIII.

8. ODONATA

Libellulidae. *Crocothemis servila* DRURY (Fig. 19)
Agrionidae. *Psolodesmus mandarinus* MACLACHLAN (Fig. 20)

a. Prothoracic Musculature

1) Dorsal Muscles

The *Psolodesmus mandarinus* and *Crocothemis servila* have three dorsal muscles on each side, a median, a lateral and an anterior. The median dorsal muscle (Fig. 20, 1) in the *Psolodesmus* is very long, attached anteriorly on the dorso-lateral portion of the posterior end of the head, and posteriorly on the median apodeme of the anterior end of the mesotergum by a wide base, that in the *Crocothemis* (Fig. 19, 1) is shorter than that of the *Psolodesmus*, and stretched between the apodeme on the middle portion of the median line of the tergum and the median apodeme of the anterior end of the mesotergum. The lateral dorsal muscle in the *Psolodesmus* (Fig. 20, 2) arises on the protergal median apodeme, that in the *Crocothemis* (Fig. 19, 2) on the

outside of the protergal median apodeme, and both take each the insertion into the anterior end of the mesotergum lateral to the median apodeme. The anterior dorsal muscle in both species (Fig. 19, **3**; Fig. 20, **3**) arises on the dorso-lateral portion of the posterior end of the head and attaches posteriorly on the protergal median apodeme.

2) Ventral Muscles

The ventral muscles (Fig. 19, **4**; Fig. 20, **4**) in both species are one-paired, arising on the ventro-lateral portions of the posterior end of the head behind the posterior tentorial arms, and attached on the profurcal arms by wide bases.

3) Ventral Transverse Muscles

The *Psolodesmus* and *Crocothemis* have a pair of ventral transverse muscles (Fig. 20, **5**; Fig. 19, **5**) very similar to those in the prothorax of the Orthoptera.

4) Tergo-Sternal Muscles

The *Psolodesmus* and *Crocothemis* have two anterior intersegmental tergo-sternal muscles (Fig. 20, **6, 7**; Fig. 19, **6, 7**) and an anterior internal tergo-sternal muscle (Fig. 20, **8**; Fig. 19, **8**) on each side. The first anterior intersegmental tergo-sternal muscle is an anterior bundle arising on the dorso-lateral portion of the posterior end of the head and attached ventrally on the posterior portion of the ventro-lateral cervical sclerite by a wide base, the second is a posterior bundle arising on the upper side of the first and inserted into the posterior portion of the ventro-lateral cervical sclerite behind the first muscle by a broad base. The anterior internal tergo-sternal muscle arises on the antero-lateral portion of the tergum, passes the inside of the anterior intersegmental tergo-sternal muscles, and is attached to about the middle portion of the ventro-lateral cervical sclerite.

5) Tergo-Pleural Muscles

The *Psolodesmus* has a pair of small ordinary tergo-pleural muscles (Fig. 20, **9**) arising on the antero-lateral portions of the tergum and inserted into the dorso-lateral portions of the pleura. The *Crocothemis* is provided with a pair of anterior tergo-pleural muscles (Fig. 19, **9**) arising on the dorso-lateral portions of the posterior end of the

head and inserted into the antero-dorsal portions of the pleura. It also has a pair of small ordinary tergo-pleural muscles (Fig. 19, **10**) very similar to those of the *Psolodesmus.*

6) Sterno-Pleural Muscles

The sterno-pleural muscles in the *Psolodesmus* and *Crocothemis* are one-paired, arising on the dorsal portions of the pleural ridges and inserted into the furcal arms (Fig. 20, **10**; Fig. 19, **11**).

7) Coxal Muscles

The *Psolodesmus* is provided with six coxal muscles on each side: A thick tergal promotor (Fig. 20, **11**) arising on the middle of the dorso-lateral region of the tergum by a wide base, and inserted into the anterior basal rim of the coxa; a slender long cervical (or anterior) sternal promotor (Fig. 20, **12**) arising on the middle portion of the ventro-lateral cervical sclerite and inserted into the anterior basal wall of the coxa; small ordinary sternal promotor (Fig. 20, **13**) arising on the base of the furcal arm by a wide base and inserted into the anterior basal rim of the coxa; two tergal remotors, a thick internal bundle (Fig. 20, **14**) arising on the middle of the dorso-lateral region of the tergum by a wide base, and a slender external bundle (Fig. 20, **15**) arising on the middle of the lateral region of the tergum, both are inserted into the postero-lateral basal rim of the coxa; a sternal remotor (Fig. 20, **16**) arising on the base of the furcal arm by a broad base and inserted into the posterior basal rim of the coxa.

The *Crocothemis* has six coxal muscles on each side: Two tergal promotors (Fig. 10, **12, 13**) arising on the anterior portion of the dorso-lateral region of the tergum and inserted into the anterior basal rim of the coxa; a cervical (or anterior) sternal promotor (Fig. 19, **14**), an ordinary sternal promotor (Fig. 19, **15**) and a sternal remotor (Fig. 19, **17**) very similar to those in the *Psolodesmus* respectively; a tergal remotor (Fig. 19, **16**) similar to the internal bundle of the tergal remotors in the *Psolodesmus.*

8) Trochanteral Muscles Arising on the Thorax

Trochanteral muscles arising on the prothorax and inserted into the common depressor apodemes of the trochanters are found in three

pairs on the *Psolodesmus*, tergal depressors, pleural depressors and sternal depressors, and in two-pairs on the *Crocothemis*, pleural depressors and sternal depressors. The tergal depressor in the *Psolodesmus* (Fig. 20, **17**) is thick, arising on the middle of the dorso-lateral region of the tergum by a wide base. The pleural depressor (Fig. 20, **18**; Fig. 19, **18**) in both species is thick, arises on the dorsal portion of the epimeron. The sternal depressor (Fig. 20, **19**; Fig. 19, **19**) of both species takes its origin on the furcal arm.

b. Mesothoracic Musculature

1) Dorsal Muscles

The dorsal muscles of the *Psolodesmus* and *Crocothemis* (Fig. 20, **20**; Fig. 19, **20**) are one-paired, arising on the anterior median apodemes of the wing bearing tergal plates and attached to the antero-lateral corners of the metaterga.

2) Ventral Muscles

The mesothoracic ventral muscles of both species are found in one pair, thick, longitudinal, and connet the prothoracic furcal arms with the mesothoracic furcal arms (Fig. 20, **21**; Fig. 19, **21**).

There is a pair of oblique chitinous bridges connecting the mesofurcal arms with the anterior end of the metasternum on both species. These bridges may show that there were muscle-stretchings in the early stage of the development.

3) Ventral Transverse Muscles

The *Psolodesmus* and *Crocothemis* have one pair of very slender anterior ventral transverse muscles arising on the lateral elongations of the anterior portion of the sternum and inserted into the spina on the median portion of the ventral intersegmental membrane between the pro- and mesosternum (Fig. 20, **22**; Fig. 19, **22**). In *Ceriagrion erubescens* SELYS (Coenagrionidae) and *Deplacodes trivialis* RAMBUR (Libellulidae) a transverse chitinous bridge connecting both sides of the sternum takes the place of the anterior ventral transverse muscles.

4) **Tergo-Sternal Muscles**

The *Psolodesmus* has two anterior tergo-sternal muscles on each side, the first (Fig. 20, **23**) is thick, arising on the dorso-lateral region of the wing-bearing tergite and inserted into the disc of the lateral region of the sternum before the furcal arm, the second (Fig. 20, **24**) is slender, arising on the dorso-lateral region of the wing-bearing tergite and inserted into the secondary disc provided with a slender long stalk arising on the disc on which the first muscle attaches. The *Crocothemis* has three anterior tergo-sternal muscles on each side, the first (Fig. 19, **23**) is very small, arising on the antero-lateral corner of the anterior tergite and inserted into the antero-lateral wing of the sternum, the second and third (Fig. 19, **24, 25**) are very similar to the first and second muscles in the *Psolodesmus* (Fig. 20, **23, 24**) respectively.

5) **Tergo-Pleural Muscles**

Six tergo-pleural muscles are found on each side of the *Psolodesmus:* A small ordinary tergo-pleural muscle (Fig. 20, **25**) arising on the anterior dorso-lateral region of the wing bearing tergite and inserted into the dorsal portion of the pleural ridge; two pleuro-axillary muscles, one (Fig. 20, **26**) arising on the dorsal portion of the pleural ridge near the ordinary tergo-pleural muscle, the other (Fig. 20, **27**) arising on the pleural wing process, and both are inserted into the posterior portion of the axillary plate (SNODGRASS, 1935); three pleuro-subalar muscles, one (Fig. 20, **28**) very thick, arising on the ventro-anterior portion of the epimeron by a wide base and inserted into the anterior apodeme on the subalar membrane, the other (Fig. 20, **29**) on the ventral portion of the epimeron and into the small apodeme on the subalar membrane behind the first muscle, still an other (Fig. 20, **30**) slender, shorter than the two others, arising on the posterior end of the epimeron and inserted into the small apodeme on the subalar membrane as in the second muscle. The tergo-pleural muscles in the *Crocothemis* (Fig. 19, **26, 27, 28, 29, 30**) are very similar to those in the *Psolodesmus* (Fig. 20, **25, 27, 28, 29, 30**) respectively, but lack the bundle corresponding to the first pleuro-axillary muscle of the *Psolodesmus* (Fig. 20, **26**).

6) **Sterno-Pleural Muscles** .

The sterno-pleural muscles in the *Psolodesmus* and *Crocothemis* are very similar to each other in their features. These are two-paired sterno-basalar muscles. The first pair (Fig. 20, **31**; Fig. 19, **31**) are very thick, arising on the lateral wings of the sterna by wide bases and attached on the basalar discs; the second pair (Fig. 20, **32**; Fig. 19, **32**) are slender, arising on the lateral wings of the sternum as the first, and taking the insertions into the small discs provided with long slender stalks standing on basalar membranes.

7) **Coxal Muscles and Coxal Wing Muscles**

Five muscles attached on the coxal basal margin are found on each side in the *Psolodesmus*; a sternal promotor of the coxa (Fig. 20, **33**), two coxo-axillary muscles (Fig. 20, **34, 35**), a sternal remotor of the coxa (Fig. 20, **36**), a pleural abductor of the coxa (Fig. 20, **37**). The sternal promotor is fan-shaped, stretching between the furcal arm and the anterior basal rim of the coxa. The first coxo-axillary muscle arises on the postero-lateral basal rim of the coxa by a wide base and attaches dorsally on the distinct sclerite at the base of the humeral plate; the second is stretched between the postero-lateral basal rim of the coxa and the apodeme of the axillary plate. The sternal remotor is small, stretched between the furcul arm and the posterior basal rim of the coxa. The pleural abductor is thick, taking its origin on the upper portion of the ventral division of the pleuron by a wide base, and its insertion into the antero-lateral basal rim of the coxa.

On the coxal basal margin of the *Crocothemis* is attached five muscles (Fig. 19, **34, 35, 36, 37, 38**) similar to those in the *Psolodesmus* (Fig. 20, **33, 34, 35, 36, 37**) respectively, and also a thick tergal promotor (Fig. 19, **33**) arising on the dorso-lateral portion of the wing-bearing tergite and inserted into the anterior basal rim of the coxa.

8) **Trochanteral Muscles Arising on the Thorax**

Two muscles arising on the thorax and attached on the common depressor apodeme of the trochanter are found on each side: A pleural depressor (Fig. 20, **38**; Fig. 19. **39**) arising on the dorsal portion (*Psolodesmus*) or posterior portion (*Crocothemis*) of the ventral

subdivision of the pleuron by a wide base; a sternal depressor (Fig. 20, **39**; Fig. 19, **40**) arising on the furcal arm.

9) Muscles of the Spiracle

The first thoracic spiracle has a small occlusor attached on the under side of the atrial chamber of the spiracle. The occlusor in the *Crocothemis* arises on the anterior margin of the mesepisternum (Fig. 19, **41**), in the *Psolodesmus* (Fig. 20, **40**) on the antero-lateral sternal sclerite.

c. Metathoracic Musculature

1) Dorsal Muscles

The metathoracic dorsal muscles in the *Psolodesmus* (Fig. 20, **41**) are very similar to those in the mesothoracics (Fig. 20, **20**). The *Crocothemis* lacks the dorsal muscles in the metathorax.

2) Ventral Muscles

There are one-paired ventral muscles arising on the furcal arms and inserted into the antero-lateral corners of the first abdominal sternum by slender tendons (Fig. 20, **42**; Fig. 19, **42**). The places of the ordinary longitudinal ventral muscles are taken by a pair of longitudinal chitinized bridges.

In addition to all the already mentioned thoracic ventral muscles, there are a pair of very long ventral muscles (Fig. 20, **43**; Fig. 19, **43**) arising on the profurcal arms and attached on the antero-lateral corners of the first abdominal sternum by very long tendons extending to the anterior end of the mesosternum.

3) Tergo-Sternal Muscles

On each side there are three muscles: The first anterior tergo-sternal (Fig. 20, **44**; Fig. 19, **44**) and the second anterior tergo-sternal muscle (Fig. 20, **45**; Fig. 19, **45**) very similer to the first and secend anterior tergo-sternal muscles (Fig. 20, **23** and **24**) in the mesothorax of the *Psolodesmus* respectively, and a posterior tergo-sternal muscle (Fig. 20, **46**; Fig, 19, **46**) arising on the antero-lateral corner of the first abdominal tergum and inserted into the furcal arm.

4) **Tergo-Pleural Muscles**

The tergo-pleural muscles in the *Psolodesmus* (Fig. 20, **47, 48, 49, 50, 51, 52**) and *Crocothemis* (Fig. 19, **47, 48, 49, 50, 51**) are very similar to their mesothoracic tergo-pleural muscles (Fig. 20, **25, 26, 27, 28, 29, 30**; Fig. 19, **26, 27, 28, 29, 30**) respectively, except that the first and second pleuro-subalar muscles of the *Crocothemis* (Fig. 19, **49, 50**) are attached ventrally on the more ventral portion of the epimeron.

5) **Sterno-Pleural Muscles**

Two sterno-basalar muscles (Fig. 20, **53, 54**; Fig. 19, **52, 53**) belonging to the sterno-pleural muscles are found on each side. They correspond to the mesothoracic sterno-basalar muscles (Fig. 20, **31, 32**; Fig. 19, **31, 32**) respectively, but the first sterno-basalar muscle (Fig. 20, **53**; Fig. 19, **52**) takes its origin on the chitinized bridge between the mesofurca and the anterior end of the metasternum, and the second sterno-basalar muscle (Fig. 20, **54**; Fig. 19, **53**) arises on a stalked small disc standing on or behind the intersegmental ridge between the ventral portions of the mesothoracic and metathoracic pleura.

6) **Coxal Muscles and Coxal Wing Muscles**

The coxal muscles and the coxal wing muscles in the *Psolodesmus* (Fig. 20, **55-59**) and *Crocothemis* (Fig. 19, **54-58**) are similar to those in their mesothorax respectively, except that the sternal promotor in the former species (Fig. 20, **55**) arises on the mesothoracic furcal arm, that the latter species lacks the muscle corresponding to its mesothoracic sternal promotor (Fig. 19, **34**).

7) **Trochanteral Muscles**

The trochanteral muscles in the *Psolodesmus* (Fig. 20, **60, 61**) and *Crocothemis* (Fig. 19, **59, 60**) are very similar to those in their mesothorax respectively.

8) **Muscles of the Spiracle**

Each second thoracic spiracle has an occlusor (Fig. 20, **62**; Fig. 19, **61**) arising on the intersegmental ridge between the ventral portions of the meso- and metapleuron, and attached on the anterior side of the spiracle.

TABLE IX

Odonata

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figures; "x" shows the displacement of muscles by chitinous bridges; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Libellulidae. *Crocothemis servila* (Fig. 19)	Agrionidae. *Psolodesmus mandarinus* (Fig. 20)	Libellulidae. *Diplax* sp. (BERLESE, 1909)	Aeschnidae. *Anax junius* Coenagrionidae. *Platythemis lydia* (MALOUF, 1935)
Dorsals Muscles.				
Median dorsals.	1 (1)	1 (1)	1(110)	1 (2)
Lateral dorsals.	1 (2)	1 (2)		—
Anterior dorsals.	1 (3)	1 (3)		1 (1)
Ventral Muscles.				
Long longitudinal ventrals.	1 (4)	1 (4)	—	1(11)
Short longitudinal (cervico-furcal) ventrals.	—	—	2(135) (135a)	—
Anterior ventrals.	—	—	—	1 (8)
Ventral Transverse Muscles.	1 (5)	1 (5)		—
Tergo-Sternal Muscles.				
Anterior intersegmental tergo-sternals.	2 (6) (7)	2 (6) (7)		2 (4) (5)
Anterior internal tergo-sternals.	1 (8)	1 (8)	1(144a)	1 (7)
Tergo-Pleural Muscles.				
Anterior tergo-pleurals.	1 (9)	—		—
Ordinary tergo-pleurals.	1(10)	1 (9)		1(12)
Sterno-Pleural Muscles.				
Furco-entopleural muscles.	1(11)	1(10)		—
Coxal Muscles.				
Tergal promotors.	2(12) (13)	1(11)	1(120)	1(13)
Anterior (cervical) sternal promotors.	1(14)	1 12)		—
Ordinary sternal promotors.	1(15)	1(13)		—
Tergal remotors.	1(16)	2(14) (15)	1(CXXI)	1(14)
Ordinary sternal remotors.	1(17)	1(16)		1(16)
Trochanteral Muscles Arising on the Thorax.				
Tergal depressors.	—	1(17)	1(117)	—
Pleural depressors.	1(18)	1(18)		1(18)
Sternal depressors.	1(19)	1(19)		1(19)

b) Pterothoracic Musculature

	Libellulidae. *Crocothemis servila* (Fig. 19)		Agrionidae. *Psolodesmus mandalinus* (Fig. 20)		Libellulidae. *Diplax sp.* (BERLESE, 1909 Fig. 475, 476)		Aeschnidae. *Anax junius* Coenagrionidae. *Platythemis lydia* (MALOUF, 1935)	
	Meso-thorax	Meta-thorax	Meso-thorax	Meta-thorax	Mesothorax	Metathorax	Meso-thorax	Meta-thorax
Dorsal Muscles.								
Lateral dorsals.	1(20)	—	1(20)	1(41)	1(LXXIV)	—	1(25)	—
Ventral Muscles.								
Longitudinal ventrals.	1(21)	—(x)	1(21)	—(x)	1(105+106)	—(x)	1(41)	—
Posterior ventrals.	—(x)	1(42)	—(x)	1(42)	—(x)	1(XXVIIa)		1(68)
Profurco-abdominal ventrals.	—	1(43)	—	1(43)	—	—	—	—
Ventral Transverse Muscles.								
Anteriors.	1(22)	—	1(22)	—	?	—	—	—
Tergo-Sternal Muscles.								
Anterior tergo-sternals.	3(23) (24) (25)	2(44) (45)	2(23) (24)	2(44) (45)	1(LXXVIII)	1(XXXVI)	1(23)	2(46) (48)
Posterior tergo-sternals,	—	1(46)	—	1(46)	—	1(41	—	1(67)
Tergo-Pleural Muscles.								
Ordinary tergo-pleurals.	1(26)	1(47)	1(25)	1(47)			1(28)	1(50)
Pleuro-axillary muscles.	1(27)	1(48)	2(26) (27)	2(48) (49)	1	1(LVIII)	2(29) (30)	2(51) (52)
Pleuro-subalar muscles.	3(28) (29) (30)	3(49) (50) (51)	3(28) (29) (30)	3(50) (51) (52)	3(LXXXIX) (LXXXVII) (85)	3(LV) (LIV) (54)	3(32) (33) (34)	3(54) (55) (56)
Sterno-Pleural Muscles.								
Sterno-basalar muscles.	2(31) (32)	2(52) (53)	2(31) (32)	2(53) (54)	2(LXXIX) (LXXX)	2(XXXVIII) (XXXIX)	2(22) (21)	2(44) (43)
Coxal Muscles and Coxal Wing Muscles.								
Tergal promotors of the coxa.	1(33)	1(54)	—	—	—	1(XLI)	—	—
Ordinary sternal promotors of the coxa.	1(34)	—	1(33)	—			—	—
Anterior furcal sternal promotors of the coxa.	—	—	—	1(55)			—	—
Coxo-axillary muscles	2(35) (36)	2(55) (56)	2(34) (35)	2(56) (57)	2(LXXXIV) (84)	2(XLIV) (XLIX)	2(26) (27)	1(49)?
Ordinary sternal remotors of the coxa,	1(37)	1(57)	1(36)	1(58)			1(38)	1(61)
Pleural abductors of the coxa.	1(38)	1(58)	1(37)	1(59)	1	1(LXVII)	1(36)	1(58)
Trochanteral Muscles Arising on the Thorax.								
Pleural depressors.	1(39)	1(59)	1(38)	1(60)			1(39)	1(62)
Sternal depressors.	1(40)	1(60)	1(39)	1(61)			1(40)	1(63)
Muscles of the Spiracle.	1(41)	1(61)	1(40)	1(62)			1(OM2)	1(OM3)

c) Abdominal Musculature

	Libellulidae. *Crocothemis servila* (Fig. 19).		Agrionidae. *Psolodesmus mandarinus* (Fig. 20)	
	I Segment	II-VI Segs.	I Segment	II-VI Segs.
Dorsal Muscles.	2(62) (63)	2(66) (67)	2(63) (64)	2(68) (69)
Ventral Muscles.	1(64)	1(68)	1(65)	1(70)
Ventral Transverse Muscles.	—	2(69) (70)	—	1(71) in II. 2(75) (76) in III-VI.
Tergo-sternal Muscles.	—	2(71) (72)	1(66)	2(72) (73)
Occlusors of the Spiracle.	1(65)	1(73)	1(67)	1(74)

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figures 19 and 20, and Table IX.

9. THYSANOPTERA

Phloeothripidae. *Machatothrips artocarpi* MOULTON (Fig. 21)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has three dorsal muscles on each side: A median muscle (Fig. 21, **1**) attached anteriorly on the posterior end of the head and posteriorly on the anterior end of the mesotergum near the dorsal median line; a lateral oblique muscle (Fig. 21, **2**) arising on the middle of the median region of the tergum along the dorsal median line by a wide base and inserted into the anterior end of the mesotergum lateral to the median muscle; an anterior oblique muscle (Fig. 21, **3**) arising on the middle of the median region of the tergum before the lateral oblique muscle by a wide base and inserted into the lateral portion of the posterior end of the head.

2) Ventral Muscles

The ventral muscles are one-paired, attached anteriorly on the

anterior portions of the ventro-lateral cervical sclerites and posteriorly on the very small furcal arms (Fig. 21, **4**).

3) **Tergo-Sternal Muscles**

Five tergo-sternal muscles are found on each side: Two anterior intersegmental tergo-sternals, one (Fig. 21, **5**) slender, arising on the dorso-lateral portion of the posterior end of the head and inserted into the anterior end of the ventro-lateral cervical sclerite, the other (Fig. 21, **6**) arising on the dorso-lateral portion of the posterior end of the head and inserted into the posterior portion of the ventro-lateral cervical sclerite by a wide base; two slender anterior internal tergo-sternals, one (Fig. 21, **7**) arising on the middle of the median region of the tergum lateral to the anterior dorsal muscle and inserted into the anterior end of the ventro-lateral cervical sclerite, the other (Fig. 21, **8**) taking its origin and insertion on the posterior side of the first; a slender posterior tergo-sternal muscle (Fig. 21, **9**) arising on the antero-lateral corner of the mesotergum and attached on the profurcal arm.

4) **Sterno-Pleural Muscles**

The sterno-pleural muscles are one-paired, very slender, arising on the furcal arm and inserted into the ventral portion of the pleural ridge (Fig. 21, **10**).

5) **Coxal Muscles**

Eleven coxal muscles are found on each side: Four tergal promotors, a sternal promotor, a tergal remotor, a posterior spinal remotor, three tergal abductors, and a pleural abductor.

The first tergal promotor (Fig. 21, **11**) is slender, arising on the dorso-lateral portion of the posterior end of the tergum and inserted into the trochantin at the coxo-trochantinal joint; the second (Fig. 21, **12**) is very slender, arising on the middle of the median region of the tergum behind the second anterior internal tergo-sternal muscle (Fig. 21, **8**), and inserted into the lateral portion of the trochantin near the coxo-trochantinal joint; the third (Fig. 21, **13**) is thick, arising on the tergum behind the second by a wide base, the fourth (Fig. 21, **14**) is slender, arising on the tergum lateral to the third, both are inserted into the

anterior basal rim of the coxa at the coxo-trochantinal joint. The sternal promotor (Fig. 21, **15**) is a slender ordinary sternal promotor stretched between the furcal arm and the anterior basal rim of the coxa near the coxo-trochantinal joint. The tergal remotor (Fig. 21, **16**) is a vertical fan-shaped muscle arising on the tergum between the dorsal ends of the third and fourth tergal promotors by a wide base, and inserted into the posterior basal rim of the coxa. The posterior spinal remotor (Fig. 21, **17**) is a slender muscle stretched between the spina at the posterior end of the sternum and the posterior basal rim of the coxa. The first tergal abductor (Fig. 21, **18**) is a thick vertical muscle arising on the portion somewhat anterior to the middle of the dorso-lateral region of the tergum by a wide base, the second (Fig. 21, **19**) is a slender muscle arising on the middle of the dorso-lateral region of the tergum, both are inserted into the antero-lateral basal rim of the coxa, and the third (Fig. 21, **20**) is thick, arising on the middle of the lateral region of the tergum by a wide base and inserted into the antero-lateral basal rim of the coxa lateral to the first and second muscles. The pleural abductor (Fig. 21, **21**) is small, arises on the anterior portion of the episternum, and attaches on the antero-lateral basal rim of the coxa as the first and second tergal abductors.

6) Trochanteral Muscles Arising on the Thorax

The trochanter has two muscles arising on the prothorax: A thick pleural depressor (Fig. 21, **22**) arising on the middle of the pleural ridge, and a slender sternal depressor (Fig. 21, **23**) on the furcal arm, and both are inserted into the common depressor apodeme of the trochanter.

b. Pterothoracic Musculature

1) Dorsal Muscles

The mesothorax has a pair of median longitudinal dorsal muscles (Fig. 21, **24**) attached on both ends of the tergum. The metathorax has a pair of lateral oblique dorsal muscles (Fig. 21, **46**) arising on

the median anterior end of the tergum and inserted into the lateral portions of the posterior end of the tergum.

2) **Ventral Muscles**

The mesothorax has a longitudinal ventral muscle (Fig. 21, **25**) arising on the posterior margin of the prosternum by a wide base and inserted into the mesofurcal arm, and a very slender spino-furcal ventral muscle (Fig. 21, **26**) arising on the spina at the median posterior end of the prosternum and inserted into the mesofurcal arm, on each side. The metathorax has a thick longitudinal ventral muscle (Fig. 21, **47**) stretched between the meso- and metafurcal arms, a long mesofurco-abdominal ventral muscle (Fig; 21, **48**) arising on the mesofurcal arm and inserted into the anterior end of the first abdominal sternum by a wide base, and a posterior ventral muscle (Fig. 21, **49**) arising on the inside of the base of the furcal arm and inserted into the anterior end of the first abdominal sternum near the ventral median line by a wide base.

3) **Tergo-Sternal Muscles**

The tergo-sternal muscles are found in three pairs on each segment: Two pairs of anterior tergo-sternals and a pair of posterior tergo-sternals. The first and second anterior tergo-sternals (Fig. 21, **27, 28**; Fig. 21, **50, 51**) are thick, vertical, arising on the anterior portion of the dorso-lateral region of the tergum and attached on the ventro-lateral sternal region. The posterior tergo-sternal muscle (Fig 21, **29**; Fig. 21, **52**) is slender, attached ventrally on the furcal arm and dorsally on the lateral anterior end of the following tergum.

4) **Tergo-Pleural Muscles**

The mesothorax has four ordinary tergo-pleural muscles and a pleuro-axillary muscle on each side: The first tergo-pleural muscle (Fig. 21, **30**) is vertical, arising on the antero-lateral portion of the tergum and inserted into the anterior triangular sclerite of the lateral region; the second (Fig. 21, **31**) is a very small muscle arising on the antero-lateral corner of the tergum and inserted into the antero-dorsal corner of the posterior episternite; the third (Fig. 21, **32**) is very small,

arising on the antero-lateral portion of the tergum behind the first muscle, and inserted into the anterior end of the dorsal division of the posterior episternite; the fourth (Fig. 21, **33**) is a vertical muscle originated on the postero-lateral portion of the tergum and attached on the pleural arm. The pleuro-axillary muscle (Fig. 21, **34**) is fan-shaped, arising on the ridge dividing the pleuron into a dorsal and a ventral region, and inserted into the third axillary sclerite.

The metathorax has two ordinary tergo-pleural muscles and a pleuro-axillary muscle on each side: The first ordinary tergo-pleural muscle (Fig. 21, **53**) is small, arising on the anterior portion of the lateral margin of the tergum and attached on the pleural ridge near the pleural wing process; the second (Fig. 21, **54**) is strong, arising on the about middle of the lateral region of the tergum, inserted into the middle of the pleural ridge, probably corresponding to the fourth ordinary tergo-pleural muscle of the mesothorax. The pleuro-axillary muscle (Fig. 21, **55**) is very slender, arising on the pleural ridge above the second ordinary tergo-pleural muscle and attached on the third axillary sclerite.

5) **Sterno-Pleural Muscles**

The mesothorax is provided with two thick sterno-basalar muscles (Fig. 21, **35, 36**) arising on the ventro-lateral sternal region outside the anterior tergo-sternal muscles and inserted into the disc on the basalar membrane, and a slender furco-entopleural muscle (Fig. 21, **37**) stretched between the furcal arm and the pleural arm.

The metathorax has three sterno-basalar muscles, a furco-entopleural muscle and a special sterno-entopleural muscle (Fig. 21, **60**), on each side: The first sterno-basalar muscle (Fig. 21, **56**) is small, arising on the antero-lateral corner of the ventral plate, the second (Fig. 21, **57**) is thick, takes its rise on the anterior portion of the ventro-lateral sternal region by a wide base, the third (Fig. 21, **58**) is thick, originating on the ventro-lateral sternal region lateral to the second by a wide base, all the three attach on the basalar sclerite, the second and third correspond to the first and second sterno-basalar muscles in the mesothorax; the furco-entopleural muscle (Fig. 21, **59**)

connects the furcal arm with the middle portion of the pleural ridge; the sterno-entopleural muscle (Fig. 21, **60**) is very slender, originating on the lateral portion of the posterior sternal plate and attached on the middle portion of the pleural ridge.

6) Coxal Muscles and Coxal Wing Muscles

Six muscles are attached on the basal rim of the coxa in the mesothorax as follows: Five coxal muscles—a very thick sternal promotor (Fig. 21, **38**) arising on the median ridge of the sternum before the furca by a wide base and inserted into the anterior basal rim of the coxa; a tergal remotor (Fig. 21, **39**) on the postero-lateral portion of the tergum by a wide base and into the posterior basal rim of the coxa; two sternal remotors arising on the furcal arm by wide base, one (Fig. 21, **41**) inserted into the posterior basal rim of the coxa, the other (Fig. 21, **42**) into the postero-lateral basal rim of the coxa; a pleural abductor (Fig. 21, **43**) originating on the anterior face of the pleural arm and attached on the antero-lateral basal rim of the coxa. A very slender coxo-subalar muscle (Fig. 21, **40**) arising on the postero-lateral basal rim of the coxa and inserted into the subalar membrane.

Seven muscles are attached on the basal rim of the coxa in meta-thorax: Six coxal muscles—two very thick sternal promotors (Fig. 21, **61, 62**) attached on the anterior basal rim of the coxa, one arising on the median portion of the sternum by a broad base, the other on the sternum lateral to the furcal arm by a wide base; a tergal remotor (Fig. 21, **63**) arising on the antero-lateral portion of the tergum and inserted into the posterior basal rim of the coxa by a slender tendon; two sternal remotors (Fig. 21, **65, 66**) and a pleural abductor (Fig. 21, **67**) very similar to those of the mesothorax. A coxo-subalar muscle (Fig. 21, **64**) very similar to that of the mesothorax.

7) Trochanteral Muscles Arising on the Thorax

A sternal depressor arising on the furcal arm and inserted into the common depressor apodeme of the trochanter is found on each side (Fig. 21, **44**; Fig. 21, **68**).

TABLE X

Thysanoptera

Phloeothripidae

Machatothrips artocarpi (Fig. 21)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1 (1)
Lateral dorsals.	1 (2)
Anterior dorsals.	1 (3)
Ventral Muscles.	
Short longitudinal (cervico furcal) ventrals.	1 (4)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2 (5) (6)
Anterior internal tergo-sternals.	2 (7) (8)
Posterior tergo-sternals.	1 (9)
Sterno-Pleural Muscles.	
Furco-entopleural muscles.	1 (10)
Coxal Muscles.	
Tergal promotors.	4 (11) (12) (13) (14)
Ordinary sternal promotors.	1 (15)
Tergal remotors.	1 (16)
Posterior spinal remotors.	1 (17)
Tergal abductors.	3 (18) (19) (20)
Pleural abductors.	1 (21)
Trochanteral Muscles Arising on the Thorax.	
Pleural depressors.	1 (22)
Sternal depressors.	1 (23)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.	1 (24)	1 (46)
Ventral Muscles.		
Longitudinal ventrals.	1 (25)	1 (47)
Spino-furcal ventrals.	1 (26)	—
Mesofurco-abdominal ventrals.	—	1 (48)
Posterior ventrals.	—	1 (49)
Tergo-sternal Muscles.		
Anterior tergo-sternals.	2 (27) (28)	2 (50) (51)
Posterior tergo-sternals.	1 (29)	1 (52)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	4 (30) (31) (32) (33)	2 (53) (54)
Pleuro-axillary muscles.	1 (34)	1 (55)
Sterno-Pleural Muscles.		
Sterno-basalar muscles.	2 (35) (36)	3 (56) (57) (58)
Furco-entopleural muscles.	1 (37)	1 (59)
Sterno-entopleurals.	—	1 (60)
Coxal Muscles and Coxal Wing Muscles.		
Ordinary sternal promotors of the coxa.	1 (38)	2 (61) (62)
Tergal remotors of the coxa.	1 (39)	1 (63)
Coxo-subalar muscles.	1 (40)	1 (64)
Ordinary sternal remotors of the coxa.	2 (41) (42)	2 (65) (66)
Pleural abductors of the coxa.	1 (43)	1 (67)
Trochanteral Muscles Arising on the Thorax.		
Sternal depressors.	1 (44)	1 (68)
Muscles of the Spiracle.	1 (45)	1 (69)

b) Abdominal Musculature

	I Segment	II–VI Segments
Dorsal Muscles.	1 (70)	1 (75)
Ventral Muscles.	1 (71)	1 (76)
Tergo-Sternal Muscles.	2 (72) (73)	2 (77) (78)
Occlusors of the Spiracle.	1 (74)	(not observed)

8) **Muscles of the Spiracles**

Each thoracic spiracle has an occlusor. The occlusor in the first spiracle (Fig. 21, **45**) is vertical, arising on the posterior portion of the mesothoracic anterior episternite and inserted into the ventral side of the spiracle, that in the second spiracle (Fig. 21, **69**) is longitudinal, attached posteriorly on the posterior portion of the metathoracic basalar sclerite and anteriorly on the posterior side of the spiracle.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Fig. 21 and Table X.

10. HEMIPTERA

Pentatomidae. *Eurostus validus* DALLAS (Fig.22)
Corixidae. *Sigara substriata* UHLER (Fig. 23)
Cicadidae. *Huechys sanguinea* (DE GEER) var. *philaemata* FABRICIUS (Fig. 24)
Jassidae. *Cicadella ferruginea* FABRICIUS (Fig. 25)
Psyllidae. *Macrohomotoma gladiatum* KUWAYAMA (Fig. 26)

a. Prothoracic Musculature

1) **Dorsal Muscles**

In the prothorax there are found three kinds of dorsal muscles, median, lateral, and anterior. The median dorsals in the *Eurostus* (Fig. 22, **1**), *Cicadella* (Fig. 25, **1**), *Macrohomotoma* (Fig. 26, **1**), are one-paired, long and thick; those of the first two species are stretched between the posterior end of the head and the first phragmata; those of the last species are short, arising on the anterior median portions of the tergum and attached on the first phragmata. The median dorsals in the *Sigara* (Fig. 23, **1, 2**) and *Huechys* (Fig. 24, **1, 2**) are two-paired, the first pair are median internal muscles similar to the median dorsal muscles in the *Eurostus* and *Cicadella*, the second pair are median external muscles arising on the median (*Sigara*) or dorso-lateral (*Huechys*) portions of the anterior end of the tergum and inserted into the first phragmata.

The lateral dorsal muscles in the *Eurostus* (Fig. 22, **2**) *Huechys* (Fig. 24, **3**), *Cicadella* (Fig, 25, **2**) and *Macrohomotoma* (Fig. 26, **2**) are one-paired, oblique, stretched between the dorso-lateral regions of the tergum and the antero-lateral corners of the mesotergum, but those in the last species are attached anteriorly on the dorsal portion of the posterior end of the head. The *Sigara* lacks the lateral dorsal muscles.

The anterior dorsal muscles are one-paired in the *Sigara*, *Huechys* and *Macrohomotoma*, two-paired in the *Eurostus*, but lack in the *Cicadella*. The attached positions of the muscles vary in different species: In the *Eurostus*, the first anterior muscle (Fig. 22, **3**) arises on the anterior portion of the tergum by a wide base, the second (Fig. 22, **4**) on the antero-lateral corner of the tergum, both are inserted into the lateral portion of the posterior end of the head; the anterior muscle in the *Sigara* (Fig. 23, **3**) is stretched between the posterior end of the head and the anterior end of the tergum near the dorsal median line; that in the *Huechys* (Fig. 34, **4**) arises on the posterior end of the head near the dorsal median line, and attaches on the oblique ridge on the ovate elevation of the dorso-lateral region of the tergum by a wide base; that in the *Macrohomotoma* (Fig. 26, **3**) is long, attached anteriorly on the posterior end of the head near the dorsal median line, posteriorly on the latero-posterior tergite by a wide base.

2) Ventral Muscles

The ventral muscles in the *Eurostus* (Fig. 22, **5**), *Sigara* (Fig. 23, **4**) and *Cicadella* (Fig. 25, **3**) are one-paired, attached anteriorly on the ventro-lateral portions of the head and posteriorly on the furcal arms; those in the *Huechys* (Fig. 24, **5, 6**) and *Macrohomotoma* (Fig. 26, **4,5**) are two-paired, the first pair in the former species as well as the first and second pairs in the latter are long longitudinal muscles attached anteriorly on the posterior tentorial arms or the ventro-lateral portions of the posterior end of the head, the second pair in the *Huechys* are external muscles arising on the anterior ends of the ventro-lateral cervical sclerites, all these are inserted into the furcal arms.

3) Tergo-Sternal Muscles

In the tergo-sternal muscles there are three kinds: Anterior intersegmental tergo-sternals, anterior internal tergo-sternals and posterior tergo-sternals. The anterior intersegmental tergo-sternal muscles are one-paired in the *Eurostus* (Fig. 22, **6**), *Huechys* (Fig. 24, **7**), *Cicadella* (Fig. 25, **4**), *Macrohomotoma* (Fig. 26, **6**), and two-paired in the *Sigara* (Fig. 23, **5**, **6**); these arise on the lateral portions of the posterior end of the head and are inserted into the anterior margins of the sterno-pleural regions anterior to the coxae (the *Eurostus*, *Sigara*, *Cicadella*), the ventro-lateral cervical sclerites (the *Huechys*) or into the antero-lateral portion of the sternum (the *Macrohomotoma*).

The anterior internal tergo-sternal muscles are one-paired in the *Sigara* (Fig. 23, **7**), three paired in the *Cicadella* (Fig. 25, **5**, **6**, **7**) and *Macrohamotoma* (Fig. 26, **7**, **8**, **9**), four-paired in the *Huechys* (Fig. 24, **8**, **9**, **10**, **11**), but lacking in the *Eurostus;* the anterior internal tergo-sternal muscle in the *Sigara* arises on the antero-median portion of the tergum by a wide base, and attaches on the ventro-lateral portion of the posterior end of the head; in the *Huechys* the first anterior internal tergo-sternal muscle (Fig. 24, **8**) arises on the anterior portion of the dorso-lateral region of the tergum and is inserted into the posterior tentorial arm, the second (Fig. 24, **9**) on the tergum behind the first and into the anterior apodeme of the ventro-lateral cervical sclerite, the third (Fig. 24, **10**) on the tergum immediately behind the second and into the posterior apodeme of the ventro-lateral cervical sclerite, the fourth (Fig. 24, **11**) on the tergum behind the third muscle and into the tentorium more anterior to the first muscle; in the *Cicadella*, the first anterior internal tergo-sternal muscle (Fig. 25, **5**) is an internal bundle arising on the anterior portion of the median region of the tergum by a wide base, the second (Fig. 25, **6**) is an external bundle arising on the anterior of the dorso-lateral region of the tergum, both are inserted into the posterior tentorial arm, and the third (Fig. 25, **7**) arises on the laterel portion of the anterior end of the mesotergum and attaches

on the outside of the base of the proboscis; in the *Macrohomotoma* (Fig. 26, **7**) the first anterior tergo-sternal muscle is slender, attached ventrally on the ventro-lateral portion of the head, the second (Fig. 26, **8**) ventrally on the lateral portion of the tentorium, both are attached dorsally on the anterior end of the dorso-lateral region of the tergum, and the third (Fig. 26, **9**) is very similar to the third muscles of the *Cicadella*.

The posterior tergo-sternal muscles in the *Eurostus* (Fig. 22, **7**), *Sigara* (Fig. 23, **8**), *Huechys* (Fig. 24, **12**) and *Cicadella* (Fig. 25, **8**) are one-paired, arise on the lateral portions of the anterior end of the mesotergum and attach on the furcal arms; those in the *Macrohomotoma* (Fig. 26, **10, 11**) are two-paired, the first pair are muscles similar to the posterior tergo-sternals in the other species, the second pair are very slender muscles stretched between the furcal arms and the posterior margins of the sclerites surrounding the first thoracic spiracles.

4) Tergo-Pleural Muscles

The *Huechys* has a pair of anterior tergo-pleural muscles (Fig. 24, **13**) arising on the lateral portions of the posterior end of the head and inserted into the bases of the pleural arms, and a pair of small vertical tergo-pleural muscles (Fig. 24, **14**) arising on the middle portions of the lateral regions of the tergum and inserted into the bases of the pleural arms; the *Cicadella* has a pair of anterior tergo-pleural muscles (Fig. 25, **9**) arising on the dorso-lateral portions of the posterior margin of the head, and inserted into the dorsal margins of the pleura; the *Macrohomotoma* is provided with a pair of small vertical tergo-pleural muscles (Fig. 26, **12**) arising on the anterior ends of the dorso-lateral regions of the tergum and attached on the anterior sides of the pleural ridges; but the *Eurostus* and *Sigara* have no tergo-pleural muscle.

5) Coxal Muscles

(a) Tergal Promotors

The *Eurostus* (Fig. 22, **8**), *Cicadella* (Fig. 25, **10**) and *Macrohomotoma* (Fig. 26, **13**) have a tergal promotor, and the *Huechys* (Fig.

24, **15**, **16**) has two tergal promotors, on each coxa, but the *Sigara* lacks the tergal promotor. The attached positions of the tergal promotors vary in different species: The tergal promotors in the *Eurostus*, *Cicadella*, and the first bundle of the tergal promotors in the *Huechys* are strong, take each the origin on the position somewhat anterior to the middle of the dorso-lateral region of the tergum and the insertion into the apodeme of the trochantin; the second bundle of the tergal promotors in the *Huechys* (Fig. 24, **16**) arises on the middle of the lateral region of the tergum by a wide base and is attached to the trochantin as the first bundle; the tergal promotor in the *Macrohomotoma* arises on the antero-lateral corner of the tergum and is inserted into the anterior basal rim of the coxa.

(*b*) *Sternal Promotors*

The *Sigara* (Fig. 23, **9**) and *Huechys* (Fig. 24, **17**) have a sternal promotor arising on the furcal arm and attached on the anterior basal rim of the coxa at the coxo-trochantinal joint, on each coxa. The *Macrohomotoma* has two sternal promotors on each coxa, and anterior muscle (Fig. 26, **14**) arising on the ventro-lateral portion of the cervical region and inserted into the anterior basal rim of the coxa, and an ordinary sternal promotor (Fig. 26, **15**) very similar to the sternal promotor in the *Huechys*. The *Eurostus* and *Cicadella* have no sternal promotor.

(*c*) *Tergal Remotors*

The tergal remotors are one-paired in the *Eurostus* (Fig. 22, **9**), two-paired in the *Sigara* (Fig. 23, **10**, **11**), *Cicadella* (Fig. 25, **11**, **12**) and *Macrohomotoma* (Fig. 26, **16**, **17**), and four-paired in the *Huechys* (Fig. 24, **18**, **19**, **20**, **21**). The tergal remotor in the *Eurostus* (Fig. 22, **9**) is fan-shaped, very thick, arising on the dorso-lateral region of the tergum behind the tergal promotor (Fig. 22, **8**), and inserted into the posterior basal rim of the coxa by a tendon. The tergal remotors in the other four species are divisible into internals and externals; in the *Sigara*, the internal bundle (Fig. 23, **10**) is thick, arising on the posterior median region of the tergum and inserted into the posterior basal rim of the coxa, the external bundle (Fig. 23, **11**) is

thick, arising on the middle of the lateral region of the tergum by a wide base and inserted into the postero-lateral basal rim of the coxa; in the *Huechys*, the internal tergal remotor (Fig. 24, **18**) is slender, arising on an oblique faint ridge on the anterior of the dorso-lateral region of the tergum, the first external tergal remotor (Fig. 24, **19**) is thick, fan-shaped, arising on the oblique ridge at the middle of the lateral region of the tergum, the second external one (Fig. 24, **20**) is the thickest of four tergal remotors, fan-shaped, arising on the tergum beneath the first external muscle, the third external one (Fig. 24, **21**) is small, takes its origin on the lateral region of the tergum beneath the second external muscle, all these are inserted into the common remotor apodeme of the posterior basal rim of the coxa; in the *Cicadella*, the inner bundle (Fig. 25, **11**) is thick, arising on the middle of the dorso-lateral region of the tergum and attached on the apodeme of the detached sclerite of the posterior basal margin of the coxa, the external one (Fig. 25, **12**) is very thick, takes its origin on the middle of the lateral region of the tergum and its insertion into the apodeme of the postero-lateral basal rim of the coxa; in *Macrohomotoma*, the internal tergal remotor (Fig. 26, **16**) arises on the posterior portion of the dorso-lateral region of the tergum by a wide base, the external one (Fig. 26, **17**) is slender, arises on the postero-lateral portion of tne tergum, both are inserted into the posterior basal rim of the coxa.

(*d*) *Sternal Remotors*

The *Sigara* (Fig. 23, **12**) and *Cicadella* (Fig. 25, **13**) have a sternal remotor, and the *Macrohomotoma* (Fig. 26, **18, 19**) has two sternal remotors, on each coxa; all these arise on the furcal arms and attach on the posterior basal rims of the coxae. The *Eurostus* and *Huechys* lack the sternal remotors.

(*e*) *Tergal Abductors*

The *Eurostus*, *Sigara*, *Huechys*, and *Cicadella* have a thick tergal abductor, and the *Macrohomotoma* has two slender tergal abductors, on each coxa. The tergal abductor in the *Eurostus* (Fig. 22, **10**) arises on the antero-lateral region of the tergum, in the *Sigara* (Fig.

23. **13**) on the anterior median region of the tergum lateral to the median ridge, in the *Huechys* (Fig. 24, **22**) and *Cicadella* (Fig. 25, **14**) on the anterior portion of the dorso-lateral region of the tergum, the first or inner tergal abductor of the *Macrohomotoma* (Fig. 26, **20**) on the middle of the dorso-lateral region of the tergum, the second or external bundle of the *Macrohomotoma* (Fig. 26, **21**) on the middle of the lateral marginal region of the tergum, and all these each take the insertion into the apodeme of the antero-lateral basal rim of the coxa.

(*f*) *Pleural Abductors*

The coxa in the *Eurostus* (Fig. 22, **11**) and *Macrohomotoma* (Fig. 26, **22**) has a pleural abductor; the muscle of the former species arises on the antero-dorsal portion of the episternum and is inserted into the antero-lateral basal rim of the coxa by a common abductor apodeme, the muscle of the latter species on the pleural arm and into the antero-lateral basal rim of the coxa. The coxa in the *Huechys* (Fig. 24, **23, 24**) and *Cicadella* (Fig. 25, **15, 16**) has two tergal abductors, the muscles in the former species arise on the pleural arm, the first and the second muscle in the latter species arise on the dorsal portion of the episternum and on the pleural arm respectively, all these take the insertion into the antero-lateral basal rim of the coxa. The *Sigara* lacks the pleural abductor.

6) Trochanteral Muscles Arising on the Thorax

(*a*) *Tergal Depressors*

The *Eurostus* (Fig. 22, **12**), *Huechys* (Fig. 24, **25**), *Cicadella* (Fig. 25, **17**) and *Macrohomotoma* (Fig. 26, **23**) have a muscle arising on the tergum and attached on the common depressor apodeme of the trochanter on each side. The dorsal attached position of the muscle varies in different species: The muscle in the *Eurostus* takes its origin on the position anterior to the middle of the lateral region of the tergum, behind the tergal promotor of the coxa, in the *Huechys* on the middle of the lateral region of the tergum, in the *Cicadella* on the anterior of the lateral region of the tergum, in the *Macrohomotoma* on the postero-lateral corner of the tergum. The *Sigara* lacks the tergal depressor.

(*b*) *Pleural Depressors*

The *Eurostus* (Fig. 22, **13**), *Sigara* (Fig. 23, **14**), *Huechys* (Fig. 24, **26**), *Cicadella* (Fig. 25, **18**) have a pleural depressor, the *Macrohomotoma* has two pleural depressors (Fig. 26, **24, 25**), on each trochanter. The muscle in the *Eurostus* is very thick, fan-shaped, arising on the dorsal portion of the pleuron, that in the *Sigara* is thick and arising on the epimeron, that in the *Huechys* and *Cicadella* originates on the pleural arm, those in the *Macrohomotoma* take their origins on the pleural ridge, and all these each take the insertion into the common depressor apodeme on the trochanter.

(*c*) *Sternal Depressors*

The sternal depressor is found on only the trochanter of the *Eurostus* (Fig. 22, **14**). It arises on the furcal arm and is attached on the common depressor apodeme of the trochanter.

b. Mesothoracic Musculature

1) Dorsal Muscles

The *Eurostus* (Fig. 22, **15, 16**), *Sigara* (Fig. 23, **15, 16**), *Huechys* (Fig. 24, **27, 28**), *Cicadella* (Fig. 25, **19, 20**), *Macrohomotoma* (Fig. 26, **26, 27, 28**) have a very thick median dorsal muscle arising on the anterior median portion of the tergum and is inserted into the median portion of the second phragma, and a thick lateral oblique dorsal muscle arising on the middle of the dorso-lateral region of the tergum and inserted into the lateral portion of the second phragma, on each side; but the latter muscle in the *Macrohomotoma* is often subdivided into two bundles (Fig. 26, **27, 28**).

2) Ventral Muscles

The ventral muscles in the *Eurostus* (Fig. 22, **17**), *Huechys* (Fig. 24, **29**), *Cicadella* (Fig. 25, **21**) and *Macrohomotoma* (Fig. 26, **29**) are one-paired, in the *Sigara* (Fig. 23, **17, 18**) are two-paired, all these are thick, longitudinal, attached anteriorly on the profurcal arms and posteriorly on the mesofurcal arms.

3) **Tergo-Sternal Muscles**

In the tergo-sternal muscles there are two kinds, anterior tergo-sternals and posterior tergo-sternals. The anterior tergo-sternal muscles are one-paired in the *Eurostus* (Fig 22, **18**), *Sigara* (Fig. 23, **19**), *Huechys* (Fig. 24, **30**) and *Cicadella* (Fig. 25, **22**), two-paired in the *Macrohomotoma* (Fig. 26, **30, 31**), and all these are very thick, arising on the anterior portions of the dorso-lateral regions of the tergum and inserted into the ventro-lateral sternal regions. The posterior tergo-sternal muscles in the five species (Fig. 22, **19**; Fig. 23, **20**; Fig. 24, **31**; Fig. 25, **23**; Fig. 26, **32**) are one-paired, stretching between the second phragmata and the mesofurcal arms.

4) **Tergo-Pleural Muscles**

In the tergo-pleural muscles are found three kinds, ordinary tergo-pleural muscles, pleuro-axillary muscles and pleuro-subalar muscles. The *Huechys* and *Macrohomotoma* have three ordinary tergo-pleural muscles, and the *Cicadella* has an ordinary tergo-pleural muscle, on each side; but the *Eurostus* and *Sigara* lack the ordinary tergo-pleural muscles. The first ordinary tergo-pleural muscle in the *Huechys* (Fig. 24, **32**) arises on the antero-lateral corner of the tergum and is inserted into the anterior margin of the episternum, in the *Macrohomotoma* (Fig. 26, **33**) on the anterior lateral margin of the main tergal plate behind the lateral end of the anterior transverse tergal ridge and into the anterior margin of the episternum; the second tergo-pleural muscle in the *Huechys* (Fig. 24, **33**) dorsally on the lateral margin of the main tergal plate anterior to the anterior notal wing process and ventrally into the dorso-anterior margin of the episternum, in the *Macrohomotoma* (Fig. 26, **34**) on a round prealar sclerite before the anterior notal wing process and into the dorsal portion of the episternum; the third tergo-pleural muscle in the *Huechys* (Fig. 24, **34**) and *Macrohomotoma* (Fig. 26, **35**) on the lateral margin of the tergum between the anterior and posterior notal wing processes and into the pleural arms. The ordinary tergo-pleural muscle in the *Cicadella* (Fig. 25, **24**) is very similar to the third ordinary tergo-pleural muscle in the *Huechys* and *Macrohomotoma*.

The pleuro-axillary muscles are one-paired in the *Eurostus* (Fig. 22, **20**), two-paired in the *Sigara* (Fig. 23, **21, 22**), *Huechys* (Fig. 24, **35, 36**), *Cicadella* (Fig. 25, **25, 26**) and *Macrohomotoma* (Fig. 26, **36, 37**). The muscles in the *Eurostus* and *Sigara* arise on the antero-dorsal portions of the episterna, in the *Huechys*, *Cicadella* and *Macrohomotoma* on the posterior portions of the episterna, all these, except the inner bundles of the *Macrohomotoma* (Fig. 26, **36**) inserted into the first axillary sclerites, attach on the third axillary sclerites.

The pleuro-subalar muscles are found in one pair on the *Huechys* (Fig. 24, **37**) and *Macrohomotoma* (Fig. 26, **38**), stretched between the epimera and the subalar sclerites. The *Eurostus*, *Sigara* and *Cicadella* lack the pleuro-subalar muscles.

5) **Sterno-Pleural Muscles**

The sterno-pleural muscles are divisible into three kinds, anterior intersegmental tergo-pleural muscles, sterno-basalar muscles, and furco-entopleual muscles. The anterior intersegmental tergo-pleural muscles are bundles of fibers arising on the anterior portions of the episterna and attached on the furcal arms of the preceding segment, these are found in one pair on the *Cicadella* (Fig. 25, **27**), but lack in the other four species. The sterno-basalar muscles are one-paired in the *Huechys* (Fig. 24, **38**), *Cicadella* (Fig. 25, **28**) and *Macrohomotoma* (Fig. 26, **39**), but lack in the *Eurostus* and *Sigara;* although these sterno-basalar muscles attach dorsally on the dorsal portion of the episterna and ventrally on the ventral plates lateral to the anterior tergo-sternal muscles, these muscles are homologous to the sterno-basalar muscles stretched between the ventral plates and the basalar sclerites or dorsal episternal detached sclerites in the other insects. The furco-entopleural muscles are bundles stretched between the furcal arms and the pleural arms, these are found in one pair on the five species (Fig. 22, **21**; Fig. 23, **23**; Fig. 24, **39**; Fig. 25, **29**; Fig. 26, **40**).

6) **Coxal Muscles and Coxal Wing Muscles**

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors are found in one pair on the five species (Fig. 22, **22**; Fig. 23, **24**; Fig. 24, **40**; Fig. 25, **30**; Fig. 26, **41**). Each

arises on the middle of the dorso-lateral region of the tergum by a wide base, and is inserted into the trochantin near the trochantinal joint by a tendon or into the anterior basal rim of the coxa (*Macrohomotoma*).

(*b*) *Sternal Promotors of the Coxae*

The *Sigara* (Fig. 23, **25**), *Huechys* (Fig. 24, **41**), *Cicadella* (Fig. 25, **31**) and *Macrohomotoma* (Fig. 26, **42**) have a sternal promotor arising on the base of the furcal arm and inserted into the anterior basal rim of the coxa on each side, but the *Eurostus* lacks the sternal promotor.

(*c*) *Tergal Remotors of the Coxae*

The *Eurostus* (Fig. 22, **23**) and *Cicadella* (Fig. 25, **32**) have a thick tergal remotor arising on the lateral portion of the tergum inside the posterior notal wing process by a wide base and inserted into the posterior basal rim of the coxa by a tendon, on each side. The *Sigara* (Fig. 23, **26, 27**), *Huechys* (Fig. 24, **42, 43**), *Macrohomotoma* (Fig. 26, **43, 44**) have two tergal remotors on each side, a thick internal bundle arising on the middle of the dorso-lateral region of the tergum and inserted into the posterior basal rim of the coxa, and an external bundle very similar to the tergal remotor in the *Eurostus* and *Cicadella.*

(*d*) *Coxo-Subalar Muscles*

The coxo-subalar muscles are one-paired in the *Eurostus* (Fig. 22, **24**), *Huechys* (Fig. 24, **44**), *Cicadella* (Fig. 25, **33**), and *Macrohomotoma* (Fig. 26, **45**), but lack in the *Sigara.* These are very thick, arising on the posterior basal rims of the coxae by wide bases, and attached on the subalar sclerites.

(*e*) *Sternal Remotors of the Coxae*

The five species (Fig. 22, **25**; Fig. 23, **28**; Fig. 24, **45**; Fig. 25, **34**; Fig. 26, **46**) have an ordinary sternal remotor arising on the furcal arm and inserted into the posterior basal rim of the coxa on each side.

(*f*) *Pleural Abductors of the Coxae and Coxo-Basalar Muscles*

The *Eurostus* (Fig. 22, **26**), *Sigara* (Fig. 23, **29**), *Huechys* (Fig. 24,

46), *Cicadella* (Fig. 25, **35**) and *Macrohomotoma* (Fig. 26, **47**) have a fan-shaped pleural abductor arising on the pleuron and attached on the antero-lateral basal rim of the coxa, on each side; the arising position of the muscle in the first four species is situated on the episternum, and in the last species on the pleural arms. The *Huechys* (Fig. 24, **47**) and *Cicadella* (Fig. 25, **36**) have a coxo-basalar muscle arising on the dorsal marginal portion of the episternum and attached on the antero-lateral basal rim of the coxa on each side, but the other three species lack the coxo-basalar muscles.

7) Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles

(*a*) *Tergal Depressors of the Trochanters*

The *Eurostus* (Fig. 22, **27**), *Sigara* (Fig. 23, **30**), *Huechys* (Fig. 24, **48**) and *Cicadella* (Fig. 25, **37**) have a tergal depressor arising on the antero-lateral portion of the tergum at the anterior inner side of the anterior notal wing process and inserted into the common depressor apodeme on the ventral base of the trochanter on each side, but the *Macrohomotoma* lacks the tergal depressor.

(*b*) *Pleural Depressors of the Trochanters and Trochantero-Basalar Muscles*

The *Eurostus* (Fig. 22, **28**) and *Cicadella* (Fig. 25, **38**) have a pleural depressor on the trochanter. It arises on the episternum (the former species) or the pleural arm (the latter species) and is inserted into the common depressor apodeme of the trochanter. The *Sigara* has two pleural depressors of the trochanter, an internal bundle (Fig. 23, **31**) arising on the dorsal portion of the episternum and inserted into the common depressor apodeme of the trochanter, an external bundle (Fig. 23, **32**) arising on the middle portion of the pleural ridge and inserted into the common depressor apodeme as the internal one, on each side. A pair of trochantero-basalar muscles connecting the dorsal margins of the episterna and the depressor apodemes of the trochanters are also found on the *Huechys* (Fig. 24, **40**). The *Macrohomotoma* has neither pleural depressor nor trochantero-basalar muscle.

(*c*) *Sternal Depressors of the Trochanters*

The *Eurostus* (Fig. 22, **29**), *Sigara* (Fig. 23, **33**), *Huechys* (Fig. 24, **50**), *Cicadella* (Fig. 25, **39**) and *Macrohomotoma* (Fig. 26, **48**) have a sternal depressor similar to that in the prothorax of the *Eurostus*, on each trochanter.

8) Muscles of the Spiracles

The first thoracic spiracle in the *Eurostus* (Fig. 22, **30**), *Huechys* (Fig. 24, **51**), *Cicadella* (Fig. 25, **40**) and *Macrohomotoma* (Fig. 26, **49**) has a small vertical occlusor arising on the ventral end of the subspiraculare and inserted into the ventral side of the atrial chamber.

c. Metathoracic Masculature

1) Dorsal Muscles

The *Eurostus* (Fig. 22, **31**) and *Huechys* (Fig. 24, **52**) have a thick median dorsal muscle stretched betweon both ends of the tergum on each side. *Cicadella* has an unpaired median dorsal muscle (Fig. 25, **41**) stretched between both ends of the tergum, and a pair of thick oblique lateral dorsal muscles (Fig. 25, **42**) arising on the middle portions of the dorso-lateral regions of the tergum and inserted into the lateral portions of the posterior end of the tergum. The *Sigara* and *Macrohomotoma* have no dorsal muscle.

2) Ventral Muscles

The *Eurostus* (Fig. 22, **32**), *Sigara* (Fig. 23, **34**), *Huechys* (Fig. 24, **53**) and *Cicadella* (Fig. 25, **43**) have a pair of longitudinal ventral muscles stretched between the mesothoracic and the metathoracic furcal arms, but the *Macrohomotoma* lacks the ventral muscles.

3) Tergo-Sternal Muscles

The *Huechys* (Fig. 24, **54**), *Cicadella* (Fig. 25, **44**) and *Macrohomotoma* (Fig. 26, **50**) have a pair of anterior tergo-sternal muscles very similar to those in their mesothorax (Fig. 24, **30**; Fig. 25, **22**; Fig. 26, **30**), but the *Eurostus* and *Sigara* lack the anterior tergo-sternal muscles. A pair of posterior tergo-sternal muscles are found on the metathorax in the *Eurostus* (Fig. 22, **33**), *Huechys* (Fig. 24, **55**),

Cicadella (Fig. 25, **45**), and *Macrohomotoma* (Fig. 26, **50a**), but lacking in the *Sigara*. The posterior tergo-sternal muscles in the *Eurostus* are very slender, they arise on the antero-lateral corners of the first abdominal tergum, attach on the odriferous sacs, and may probably serve as the dilators of the odriferous sacs; those in the *Huechys* and *Cicadella* arise on the antero-lateral corners of the first abdominal tergum and attach on the furcal arms; those in the *Macrohomotoma* are very short, they connect the intersegmental ridge between the metatergum and the first abdominal tergum near the dorsal median line with the dorsal portions of the furcal arms.

4) **Tergo-Pleural Muscles**

The *Huechys* (Fig. 24, **56**) and *Cicadella* (Fig. 25, **46**) have a pair of ordinary tergo-pleural muscles arising on the lateral portions of the tergum posterior to the anterior notal wing processes, and inserted into the pleural arms (*Huechys*) or ridges (*Cicadella*) near the pleuro-coxal joints; the *Macrohomotoma* has a pair of ordinary tergo-pleural muscles (Fig. 26, **51**) arising on the antero-lateral corners of the tergum and attached on the dorsal portions of the episterna; but the *Eurostus* and *Sigara* have no ordinary tergo-pleural muscle.

The *Eurostus* (Fig. 22, **34**) has a pair of pleuro-axillary muscles, the *Sigara* (Fig. 23, **35, 36**), *Huechys* (Fig. 24, **57, 58**), *Cicadella* (Fig. 25, **47, 48**) and *Macrohomotoma* (Fig. 26, **52, 53**) have two pairs of pleuro-axillary muscles. The pleuro-axillary muscles in the *Eurostus* arise on the antero-dorsal portions of the episterna; the first and second pleuro-axillary muscles in the *Sigara* on the basalar sclerites and on the pleural ridges respectively; the pleuro-axillary muscles in the *Huechys* on the pleural ridges; the first and second pleuro-axillary muscles in the *Cicadella* on the dorsal portions of the pleural ridges and on the epimera near the pleural ridges respectively; one pair (Fig. 26, **52**) in the *Macrohomotoma* arise on the episterna immediately forward the pleuro-coxal articulations, and the other (Fig. 26, **53**) on the episterna before the preceding muscles; all these, except the bundles in the *Macrohomotoma* (Fig. 26, **52**) inserted into the first axillary sclerites, attach on the third axillary sclerites.

5) Sterno-Pleural Muscles

The *Huechys* has an anterior intersegmental sterno-pleural muscle (Fig. 24, **59**) arising on the mesofurcal arm and attached on the anterior end of the metathoracic episternum, and a furco-entopleural muscle (Fig. 24, **60**) stretched between the furcal arm and the pleural arm, the *Macrohomotoma* has a sterno-basalar muscle (Fig. 26, **54**) arising on the antero-lateral wing of the sternal region anterior to the coxa and attached on the basalar sclerite, and a furco-entopleural muscle (Fig. 26, **55**) similar to that in the *Huechys*, on each side. The *Eurostus*, *Sigara* and *Cicadella* have no sterno-pleural muscle.

6) Coxal Muscles and Coxal Wing Muscles

(a) Tergal Promotors of the Coxae

The tergal promotors are two-bundled in the *Eurostus* (Fig. 22, **35, 36**), one-bundled in the *Sigara* (Fig. 23, **37**), *Huechys* (Fig. 24, **61**) and Cicadella (Fig. 25, **49**), but lacking in the *Macrohomotoma*. The first tergal promotor (Fig. 22, **35**) in the *Eurostus* arises on the second phragma by a wide base, the second (Fig. 22, **36**) on the antero-lateral portion of the tergum by a wide base; the tergal promotor in the *Sigara* (Fig. 23, **37**) on the antero-median portion of the tergum; that in the *Huechys* (Fig. 24, **61**) on the anterior end of the dorso-lateral region of the tergum; that in the *Cicadella* (Fig. 25, **49**) on the antero-lateral portion of the tergum behind the anterior tergo-sternal muscle; all these promotors each, except the tergal promotor of the *Sigara* attached on the anterior coxal rim, take the insertion into the trochantin.

(b) Pleural Promotors of the Coxae

On each coxa in the *Eurostus* (Fig. 22, **37**) and *Huechys* (Fig. 24, **62**) is found a pleural promotor arising on the lower portion of the episternum by a wide base, and inserted into the apex of the trochantin. The coxae in the *Sigara*, *Cicadella* and *Macrohomotoma* lack the pleural promotors.

(c) Sternal Promotors of the Coxae

The *Eurostus* (Fig. 22, **38**), *Sigara* (Fig. 23, **38**), *Huechys* (Fig. 24, **63**) and *Cicadella* (Fig. 25, **50**) have an ordinary sternal promotor

arising on the furcal arm and inserted into the anterior basal rim of the coxa on each side, but the *Macrohomotoma* lacks it.

(*d*) *Tergal Remotors of the Coxae*

The *Sigara* and *Macrohomotoma* have a thick tergal remotor, and the *Eurostus*, *Huechys* and *Cicadella* have two tergal remotors, on each coxa. The tergal remotor in the *Sigara* (Fig. 23, **39**) arises on the middle of the median region of the tergum; that in the *Macrohomotoma* (Fig. 26, **56**) on the latero-posterior portion of the tergum; the first tergal remotor in the *Eurostus* (Fig. 22, **39**) on the second phragma, the second (Fig. 22, **40**) on the anterior end of the dorso-lateral region of the tergum; the first tergal remotor in the *Huechys* (Fig. 24, **64**) on the middle of the dorso-lateral region of the tergum, the second (Fig. 24, **65**) on the tergum behind the first; the first tergal remotor in the *Cicadella* (Fig. 25, **51**) on the latero-anterior portion of the tergum, the second (Fig. 25, **52**) on the middle of the lateral region of the tergum; all these each take the insertion into the posterior basal rim of the coxa.

(*e*) *Coxo-Subalar Muscles*

The *Eurostus* (Fig. 22, **41**), *Huechys* (Fig. 24, **66**), *Cicadella* (Fig. 25, **53**) and *Macrohomotoma* (Fig. 26, **57**) have a coxo-subalar muscle attached dorsally on the subalare and ventrally on the postero-lateral basal rim of the coxa or on the posterior wall of the coxa (*Eurostus*), on each side, but the *Sigara* lacks it.

(*f*) *Sternal Remotors of the Coxae*

The *Eurostus* (Fig. 22, **42**), *Huechys* (Fig. 24, **67**) and *Macrohomotoma* (Fig. 26, **58**) have an ordinary sternal promotor stretched between the furcal arm and the posterior coxal basal rim on each side, but the *Sigara* and *Cicadella* have no sternal promotor.

(*g*) *Pleural Abductors of the Coxae*

A thick fan-shaped pleural abductor arising on the anterior portion of the episternum by a wide base and inserted into the antero-lateral basal rim of the coxa is found on each side in the *Eurostus* (Fig. 22, **43**), *Huechys* (Fig. 24, **68**) and *Cicadella* (Fig. 25, **54**), but lacking in the *Sigara* and *Macrohomotoma*.

7) Trochanteral Muscles Arising on the Thorax

(a) Tergal Depressors

The *Eurostus* (Fig. 22, **44**), *Sigara* (Fig. 23, **40**) and *Cicadella* (Fig. 25, **55**) have a thick tergal depressor of the trochanter, and the *Huechys* has two tergal depressors of the trochanter, on each side, but the *Macrohomotoma* lacks it. The tergal depressor in the *Eurostus* (Fig. 22, **44**) arises on the anterior end of the dorso-lateral region of the tergum, that in the *Sigara* (Fig. 23, **40**) and *Cicadella* (Fig. 25, **55**) is very thick, arises on the anterior median portion of the tergum; the first tergal depressor in the *Huechys* (Fig. 24, **69**) originates on the second phragma, the second (Fig 24, **70**) on the anterior portion of the dorso-lateral region of the tergum; all these each take the insertion into the depressor apodeme of the trochanter.

(b) Plerual Depressors

A very thick pleural depressor arising on the dorsal portion of the episternum by a wide base and inserted into the common depressor apodeme of the trochanter is found on each side in the *Eurostus* (Fig. 22, **45**), *Sigara* (Fig. 23, **41**), *Huechys* (Fig. 24, **71**) and *Cicadella* (Fig. 25, **56**), but lacking in the *Macrohomotoma*.

(c) Sternal Depressors

The *Eurostus* (Fig. 22, **46**), *Sigara* (Fig. 23, **42**), *Huechys* (Fig. 24, **72**) and *Cicadella* (Fig. 25, **57**) have a sternal depressor, and the *Macrohomotoma* (Fig. 26, **59**, **60**) has two sternal depressors on each trochanter. The sternal depressors in the first three species and the fifth species arise on the furcal arms, the sternal depressor in the fourth species is a special muscle arising on the mesofurcal arm, all these attach on the depressor apodemes of the trochanters.

8) Muscles of the Spiracles

Each second thoracic spiracle in the *Eurostus* (Fig. 22, **47**), *Huechys* (Fig. 24, **73**), *Cicadella* (Fig. 25, **58**) and *Macrohomotoma* (Fig. 26, **61**) has a small occlusor arising on the ventro-lateral portion of the intersegmental ridge between the meso- and metathorax or on the

antero-ventral portion of the episternum (*Macrohomotoma*) and attached on the ventral end of the spiracle.

The thoracic muscles are tabulated below, including those of some other species observed by other authors.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figs. 22-26 and Table XI.

TABLE XI

Hemiptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figures; "x" shows the displacement of muscles by chitinous bridges; "—" shows the absence of muscles)

a) Prothoracic

	Pentatomidae. *Eurostus validus* (Fig. 22)	Pentatomidae. *Nezara viridula* (MALOUF, 1933)	Corixidae. *Sigara substriata* (Fig. 23)
Dorsal Muscles.			
Median dorsals.	1 (1)	1(TL1)	2 (1) (2)
Lateral dorsals.	1 (2)	1(PrL1)	—
Anterior dorsals.	2 (3) (4)	3(M.1) (M.2) (M.3)	1 (3)
Ventral Muscles.			
Internal ventrals.	1 (5)	1(SL1)	1 (4)
External ventrals.	—	—	—
Tergo-Sternal Muscles.			
Anterior intersegmental tergo-sternals.	1 (6)	1(M.4)	2 (5) (6)
Anterior internal tergo-sternals.	—	—	1 (7)
Posterior tergo-sternals.	1 (7)	1(TSF1)	1 (8)
Tergo-pleural Muscles.			
Anterior tergo-pleural muscles.	—	—	—
Ordinary tergo-pleurals.	—	—	—
Sterno-Pleural Muscles.			
Furco-entopleurals.	—	—	—(x)
Coxal Muscles.			
Tergal promotors.	1 (8)	1(TPrCx1)	—
Anterior (cervical) sternal promotors.	—	—	—
Ordinary sternal promotors.	—	1(SPrCxl)	1 (9)
Tergal remotors.	1 (9)	1(TRrCx1)	2(10) (11)
Ordinary sternal remotors.	—	1(sternal remotor)	1(12)
Tergal abductors.	1(10)	—	1(13)
Pleural abductors.	1(11)	—	—
Trochanteral Muscles Arising on the Thorax.			
Tergal depressors.	1(12)	1(DrTrT1)	—
Pleural depressors.	1(13)	1(DrTrPl1)	1(14)
Sternal depressors.	1(14)	—	—

Musculature

Cicadidae. *Huechys sanguinea* var. *philaemata* (Fig. 24)	Cicadidae. *Cicada plebeia* (BERLESE, 1909)	Jassidae. *Cicadella ferruginea* (Fig. 25)	Psyllidae. *Macrohomotoma gladiatum* (Fig. 26)	Psyllidae. *Psylla mali* (WEBER, 1929)
2 (1)	2(140)	1 (1)	1 (1)	1(Idlm1)
(2)	(CIX)			
1 (3)	2(110)	1 (2)	1 (2)	—
	(CXII)			
1 (4)	2(CXXXVI)	—	1 (3)	2(Odlm1)
	(CXXXV)			(Odlm2)
1 (5)	2(136)	1 (3)	2 (4)	3(Ovlm1)
			(5)	(Ovlm2)
				(Ovlm3)
1 (6)	1(CXXXI)	—	—	-
1 (7)	1(147)	1 (4)	1 (6)	—
4 (8)	3(CXXXV)	3 (5)	3 (7)	3(Odlm3)
(9)	(CXXXVa)	(6)	(8)	(Oism1)
(10)	(144)	(7)	(9)	(Oism2)
(11)				
1(12)	1(112)	1 (8)	2(10)	2(Idvm1)
			(11)	(Idvm2)
1(13)	—	1 (9)	—	—
1(14)	—	—	1(12)	—
—(x)	—(x)	—(x)	—	1(Izm)
2(15)	1(113)	1(10)	1(13)	---
(16)				
—	—	—	1(14)	—
1(17)	—	—	1(15)	—
4(18)	1(116)	2(11)	2(16)	1(Ipm2)
(19)		(12)	(17)	
(20)				
(21)				
—		1(13)	2(18)	1(Ibm3)
			(19)	
1(22)		1(14)	2(20)	—
			(21)	
2(23)		2(15)	1(22)	1(Ipm1)
(24)		(10)		
1(25)	1(115)	1(17)	1(23)	—
1(26)		1(18)	2(24)	—
			(25)	
—		—	—	1(Ibm2)

b) Mesothoracic

	Pentatomidae. *Eurostus validus* (Fig. 22)	Pentatomidae. *Nezara viridula* (MALOUF, 1933)	Corixidae. *Sigara substriata* (Fig. 23)
Dorsal Muscles.			
Median dorsals.	1(15)	1(TL2)	1(15)
Lateral dorsals.	1(16)	1(TLOb2)	1(16)
Ventral Muscles.			
Longitudinal ventrals.	1(17)	1(SL2)	2(17) (18)
Spino-furcal ventrals.	—	—	—
Tergo-Sternal Muscles.			
Anterior tergo-sternals.	1(18)	1(TS2)	1(19)
Posterior tergo-sternals.	1(19)	1(TSF2)	1(20)
Tergo-Pleural Muscles.			
Ordinary tergo-pleurals.	—	—	—
Pleuro-axillary muscles.	1(20)	1(FLW2)	2(21) (22)
Pleuro-subalar muscles.	—	—	—
Sterno-Pleural Muscles.			
Ordinary sterno-pleural muscles	—	—	—
Sterno-basalar muscles.	—	—	—
Furco-entopleural muscles.	1(21)	1(SP1Ap2)	1(23)
Coxal Muscles and Coxal Trochantinal Wing Muscles.			
Tergal promotors of the coxa.	1(22)	1(TPrCx2)	1(24)
Trochantino-basalar muscles.	—	—	—
Ordinary sternal promotors of the coxa.	—	1 SPrCx2)	1(25)
Tergal remotors of the coxa.	1(23)	1(TRrCx2)	2(26) (27)
Coxo-subalar muscles.	1(24)	1(FLW2)	
Ordinary sternal remotors of the coxa.	1(25)	1(SRrCx2)	1(28)
Pleural abductors of the coxa.	1(26)	—	1(29)
Coxo-basalar muscles.	—	—	—
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.			
Tergal depressors of the trochanter.	1(27)	1(DrTrT2)	1(30)
Pleural depressors of the trochanter.	1(28)	1(DrTrP12)	2(31) (32)
Trochantero-basalar muscles.	—	—	—
Sternal depressors of the trochanter.	1(29)	—	1(33)
Muscles of the Spiracle.	1(30)	1(OcSp2)	

Musculature

Cicadidae. *Huechys sanguinea* var. *philaemata* (Fig. 24)	Cicadidae. *Cicada plebeia* (BERLESE, 1909)	Jassidae. *Cicadella ferruginea* (Fig. 25)	Psyllidae. *Macrohomotoma gladiatum* (Fig. 26)	Psyllidae. *Psylla mali* (WEBER, 1929)
1(27)	1(70)	1(19)	1(26)	1(IIdlm1)
	(69)			
1(28)	1(71)	1(20)	2(27)	2(IIdlm2)
			(28)	
1(29)	1(105+106)	1(21)	1(26)	2(Ivlm1)
				(Ivlm2)
—	1(104)	—	—	—
1(30)	1(LXXVIII)	1(22)	2(30)	2(IIdvm1)
			(31)	(IIdvm2)
1(31)	1(73)	1(23)	1(32)	1(IIism)
3(32)	2(XCI)	1(24)	3(33)	1(IIpm7)
(33)	(86)		(34)	
(34)			(35)	
2(35)	2(XCIII)	2(25)	2(36)	1(IIpm3)
(36)	(CXII)	(26)	(37)	
1(37)	—	—	1(38)	2(IIpm3)
				(IIpm4)
—	—	1(27)	—	—
1(38)	1(91)	1(28)	1(39)	2(IIpm1)
				(IIpm2)
1(39)	1(100)	1(29)	1(40)	1(IIzm)
1(40)	1(74?)	1(30)	1(41)	1(IIdvm3)
—	1(79+80)	—	—	—
1(41)	2(LXXXII)	1(31)	1(42)	1(IIbm1)
2(42)	(75)	1(32)	2(43)	—
(43)	1(84)		(44)	
1(44)		1(33)	1(45)	—
1(45)		1(34)	1(46)	1(IIbm3)
1(46)		1(35)	1(47)	2(IIpm5)
				(IIpm6)
1(47)	1(82)	1(36)	—	—
1(48)	1(76)	1(37)	—	—
—	—	1(38)	—	—
1(49)	1(81)	—	—	—
1(50)		1(39)	1(48)	1(IIbm2)
1(51)		1(40)	1(49)	

c) Metathoracic

	Pentatomidae. *Eurostus validus* (Fig. 22)	Pentatomidae. *Nezara viridula* (MALOUF, 1933)	Corixidae. *Sigara substriata* (Fig. 23)
Dorsal Muscles.			
Median dorsals.	1(31)	1(TL3)	—
Lateral dorsals.	—	—	—
Ventral Muscles.			
Longitudinal ventrals.	1(32)	—	1(34)
Tergo-Sternal Muscles.			
Anterior tergo-sternals.	—	—	—
Posterior tergo-sternals.	1(33)	1(TSF3)	—
Tergo-Pleural Muscles.			
Ordinary tergo-pleurals.	—	—	—
Pleuro-axirally muscles.	1(34)	1(F1W3)	2(35) (36)
Sterno-Pleural Muscles.			
Ordinary sterno-pleurals.	—	—	—
Sterno-basalar muscles.	—	—	—
Furco-entopleural muscles.	—	—	—
Coxal Muscles and Coxal Wing Muscles.			
Tergal promotors of the coxa.	2(35) (36)	3(TPrCx31, TPrCxII, TPrCxI+II)	1(37)
Pleural promotors of the coxa.	1(37)	—	—
Ordinary sternal promotors of the coxa.	1(38)	3(SPrCx1) (SPrCx2) (SPrCx3)	1(38)
Tergal remotors of the coxa.	2(39) (40)	2(TRrCx31) (TRrCx 3)	1(39)
Coxo-subalar muscles.	1(41)	1(DrW3)	—
Ordinary sternal remotors of the coxa.	1(42)	1(SRrCx3)	—
Pleural abductors of the coxa.	1(43)		—
Trochanteral Muscles Arising on the Thorax.			
Tergal depressors.	1(44)	1(DrTrT3)	1(40)
Pleural depressors.	1(45)	1	1(41)
Sternal depressors.	1(46)	—	1(42)
Mesofurcal depressors.	—	—	—
Muscles of the Spiracle.	1(47)	1(OrSp3)	

Musculature

Cicadidae. *Huechys sanguinea* var. *philaemata* (Fig. 24)	Cicadidae. *Cicada plebeia* (BERLESE, 1909)	Jassidae. *Cicadella ferruginea* (Fig. 25)	Psyllidae. *Macrohomotoma gladiatum* (Fig. 26)	Psyllidae. *Psylla mali* (WEBER, 1929)
1(52)	1(37)	1(41)	—	1(IIIdlm)
—	—	1(42)	—	—
1(53)	1(68)	1(43)	—	—
1(54)	1(XXXVI)	1(44)	1(50)	1(IIIdvm)
1(55)	1(XXXVII)	1(45)	1(50a)	2(IIIism1) (IIIism2)
1(56)	—	1(46)	1(51)	—
2(57) (58)	1(56)	2(47) (48)	2(52) (53)	(?)
1(59)	—	—	—	—
—	—	—	1(54)	1(IIIpm1)
1(60)	1(65)	—	1(55)	—
1(61)	1(42?)	1(49)	—	—
1(62)	1(48+49)	—	—	—
1(63)		1(50)	—	—
2(64) (65)	2(44) (43)	2(51) (52)	1(56)	—
1(66)	1(XLIX)	1(53)	1(57)	(?)
1(67)	1(61)	—	1(58)	1(IIIbm3)
1(68)		1(54)	—	—
2(69) (70)	2(XLV) (46)	1(55)	—	—
1(71)		1(56)	—	—
1(72)		—	2(59) (60)	3(IIIbm1) (IIIbm2) (IIIcox1b+c)
—		1(57)	—	—
1(73)		1(58)	1(61)	

d) Abdominal Musculature

	Pentatomidae. *Eurostus validus* (Fig. 22)	Corixidae. *Sigara substriata* (Fig. 23)	Cicadidae. *Huechys sanguinea* var. *philaemata* (Fig. 24)	Jassidae. *Cicadella ferruginea* (Fig. 25)	Psyllidae. *Macrohomotoma gladiatum* (Fig. 26)
I Segment					
Dorsal Muscles.	1(48)	1(43)	1(74)	1(59)	2(62) (63)
Ventral Muscles.	1(49)	1(44)	2(75) (76)	2(60) (61)	2(64) (65)
Tergo-Sternal Muscles.	2(50) (51)	1(45)	2(77) (78)	2(62) (63)	—
Occlusors of the Spiracle.	(52)		1(79)	1(64)	1(66)
II Segment					
Dorsal Muscles.	1(53)	1(46)	1(80)	3(65) (66) (67)	3(67) (68) (69)
Dorsal Transverse Muscles.	—	—	1(81)	1(68)	—
Ventral Muscles.	—	1(47)	1(82)	1(69)	2(70) (71)
Tergo-Sternal Muscles.	1(54)	1(48)	2(83) (84)	3(70) (71) (72)	2(72) (73)
Occlusors of the Spiracle.	1(55)		1(85)	1(73)	1(74)
III-VI Segments					
Dorsal Muscles.	1(56)	1(49)	3(86) (87) (88)	3(74) (75) (76)	2(75) (76)
Dorsal Transverse Muscles.	—in III, IV. 1(59) in V, VI.	1(50)	1(89)	1(77)	—in III. 1(82) in IV-VI.
Ventral Muscles.	—	1(51)	1(90)	1(78)	1(77)
Tergo-Sternal Muscles.	1(57)	1(52)	2(91) (92)	3(79) (80) (81)	2(78) (79)
Tergo-Pleural Muscles.	—	—	—	—	1(80) in III. 2(83) (80) in IV-VI.
Occlusors of the Spiracle.	1(58)		1(93)	1(82)	1(81)

11. NEUROPTERA

The thoracic muscles of *Chauliodes formosanus* observed previously by the author are here tabulated for convenience of comparing them with those of other insects.

TABLE XII

Neuroptera
Corydalidae
Chauliodes formosanus (MAKI, 1936)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "x" shows the displacement of muscles by chitinous briges; "—" shows the absence of muscles)

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1(53)
Lateral dorsals.	5(54)
	(55)
	(56)
	(57)
	(58)
Anterior dorsals.	2(59)
	(60)
Ventral Muscles.	
Internal longitudinal ventrals.	1(61)
External ventrals.	1(62)
Ventral Transverse Muscles.	1(63)
Tergo-Sternal Musclss.	
Anterior intersegmental tergo-sternals.	4(67)
	(69)
	(70)
	(71)
Anterior internal tergo-sternals.	3(64)
	(65)
	(66)
Anterior external tergo-sternals.	2(72)
	(73)
Posterior tergo-sternals.	1(68)
Tergo-Pleural Muscles.	
Ordinary tergo-pleurals.	6(74)
	(75)
	(76)
	(77)
	(78)
	(79)
Sterno-Pleural Muscles.	
Furco-entopleural muscles.	— (x)
Coxal Muscles.	
Tergal promotors.	2(80)
	(81)
Anterior (cervical) sternal promotors.	1(84)
Ordinary sternal promotors.	1(85)
Tergal remotors.	1(82)
Pleural remotors.	1(83)
Ordinary sternal remotors.	1(86)
Pleural abductors.	1(87)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	3(102)	3(152)
	(103)	(153)
	(105)	(155)
Lateral dorsals.	2(104)	2(154)
	(106)	(156)
Ventral Muscles.		
Longitudinal ventrals.	1(107)	1(157)
Oblique lateral ventrals.	1(108)	1(158)
Ventral Transverse Muscles.		
Anteriors.	1(109)	1(159)
Posteriors.	1(110)	1(160)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	2(112)	2(162)
	(113)	(163)
Posterior tergo-sternals.	1(111)	1(161)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	5(114)	5(164)
	(115)	(165)
	(116)	(166)
	(117)	(167)
	(118)	(168)
Pleuro-axillary muscles.	2(119a)	2(169a)
	(119b)	(169b)
Pleuro-subalar muscles.	1(120)	1(170)
Sterno-Pleural Muscles.		
Ordinary sterno-pleurals.	2(122)	2(172)
	(123)	(173)
Sterno-basalar muscles.	1(124)	1(174)
Furco-entopleural muscles.	2(125)	2(175)
	(126)	(176)
Coxal Muscles, Coxal and Trochanteral Wing Muscles.		
Tergal promotors of the coxa.	1(127)	1(177)
Trochantino-basalar muscles.	1(135)	1(185)
Ordinary sternal promotors of the coxa.	1(131)	1(181)
Tergal remotors of the coxa.	3(128)	3(178)
	(129)	(179)
	(130)	(180)
Coxo-subalar muscles.	1(136)	1(186)
Ordinary sternal remotors of the coxa	1(132)	1(182)
Pleural abductors of the coxa.	1(133)	1(183)
Coxo-basalar muscles.	1(134)	1(184)

Prothoracic Musculature		Pterothoracic Musculature		
			Mesa-thorax	Meta-thorax
Trochanteral Muscles Arising on the Thorax.		Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.		
Sternal depressors.	1(88)	Tergal depressors of the trochanter.	1(137)	1(187)
		Trochantero-basalar muscles.	1(138)	1(188)
		Sternal depressors of the trochanter.	1(139)	1(189)
		Muscles of the spiracle.	1(121)	1(171)

12. MECOPTERA

Panorpidae. *Neopanorpa ophthalmica* NAVAS (Fig. 27)

a. Prothoracic Musculature

1) Dorsal Muscles

A pair of median dorsal muscles arising on the dorsal cervical sclerites immediately behind the head by slender tendons and inserted into the first phragmata (Fig. 27, **1**) are found on the prothorax.

2) Ventral Muscles

The ventral muscles are two-paired, the first pair are thick internal ventral muscles (Fig. 27, **2**) arising on the posterior end of the ventral portion of the head, the second pair are slender external ventral muscles (Fig. 27, **3**) attached anteriorly on the inside of the ventro-lateral cervical sclerites, both pairs are attached on the furcal arms.

3) Ventral Transverse Muscle

A slender ventral transverse muscle (Fig. 27, **4**) is stretched between the furcal arms of both sides directly.

4) Tergo-Sternal Muscles

On each side there are two anterior intersegmental tergo-sternal muscles (Fig. 27, **5**, **6**), two anterior internal tergo-sternal muscles (Fig. 2, **7**, **8**) and a posterior tergo-sternal muscle (Fig. 27, **9**).

The first anterior intersegmental tergo-sternal muscle (Fig. 27, **5**) arises on the ventro-lateral cervical sclerite by a very wide base, the second (Fig. 27, **6**) is slender, originated on the furcal arm, both are inserted into the dorsal cervical sclerite immediately behind the head. The first anterior internal tergo-sternal muscle (Fig. 27, **7**) attaches dorsally on the dorso-lateral region of the tergum along the posterior transverse tergal ridge, and ventrally on the middle of the inside of the ventro-lateral cervical sclerite internally to the first anterior intersegmental tergo-sternal muscle (Fig. 27, **5**); the second (Fig. 27, **8**) is slender, arises on the antero-lateral corner of the mesotergum and attaches on the ventro-lateral cervical sclerite immediately behind the first muscle. The posterior tergo-sternal muscle (Fig. 27, **9**) is very slender, stretched between the antero-lateral corner of the mesotergum and the profurcal arm.

5) **Tergo-Pleural Muscles**

Three ordinary tergo-pleural muscles are found on each side: Two internal muscles (Fig. 27, **10, 11**) arising on the dorso-lateral region of the tergum and inserted into the dorsal end of the pleuron, an external muscle (Fig. 27, **12**) originated on the anterior margin of the dorso-lateral region of the tergum and inserted into the dorsal end of the pleuron.

6) **Coxal Muscles**

The prothorax has seven coxal muscles on each side: A long cervical (or anterior) sternal promotor (Fig. 27, **13**) arising on the anterior portion of the ventro-lateral cervical sclerite and inserted into the anterior basal rim of the coxa of the opposite side; an ordinary sternal promotor (Fig. 27, **14**) on the median ridge of the main sternal plate and into the anterior basal rim of the coxa; two tergal remotors, an internal bundle (Fig. 27, **15**) on the postero-lateral portion of the tergum and into the posterior basal rim of the coxa, an external bundle (Fig. 27, **16**) on the postero-lateral portion of the tergum as the internal bundle and into the postero-lateral basal rim of the coxa; two ordinary sternal remotors, one (Fig. 27, **17**) on the base of the

furcal arm and into the posterior basal rim of coxa, the other (Fig. 27, **18**) on the furcal arm and into the postero-lateral basal rim of the coxa; a pleural abductor (Fig. 27, **19**) on the dorsal portion of the episternum by a wide base and into the antero-lateral basal rim of the coxa.

7) Trochanteral Muscles Arising on the Thorax

On each side of the prothorax are three depressors of the trochanter: Two pleural depressors, one (Fig. 27, **20**) arising on the dorsal portion of the episternum, the other (Fig. 27, **21**) on the ventral portion of the pleural ridge beneath the pleural arm; a sternal depressor (Fig. 27, **22**) on the furcal arm; all these attach on the common depressor apodeme of the ventral base of the trochanter.

b. Pterothoracic Musculature

1) Dorsal Muscles

Each segment has two pairs of dorsal muscles, the first pair (Fig. 27, **23, 53**) are thick median longitudinal bundles stretched between the phragmata of both ends of the tergum, the second (Fig. 27, **24, 54**) are lateral oblique bundles arising on the scutum at the antero-lateral sides of the scutellum and attached on the lateral portions of the intersegmental ridge of the posterior end of the tergum.

2) Ventral Muscles

The mesothorax has two pairs of ventral muscles, the first pair (Fig. 27, **25**) are longitudinal muscles stretched between the profurcal and mesofurcal arms, the second pair (Fig. 27, **26**) are very slender spino-furcal ventral muscles arising on the posterior median end of the prosternum and inserted into the mesofurcal arms. The metathorax has a pair of longitudinal ventral muscles (Fig. 27, **55**) similar to those in the mesothorax, but lacks the spino-furcal ventral muscles.

3) Ventral Transverse Muscles

The mesothorax has a pair of posterior ventral transverse mus-

cles (Fig. 27, **27**) arising on the furcal arms; the metathorax has two pairs of ventral transverse muscles, anterior (Fig. 27, **56**) and posterior (Fig. 27, **57**), the anterior pair arise on the anterior latero-ventral intersegmental membranes of the segment, the posterior pair are very similar to the posterior ventral transverse muscles in the mesothorax; all these join to the formation of the common ventral muscular net above the ventral nerve cord.

4) **Tergo-Sternal Muscles**

A thick anterior tergo-sternal muscle arising on the antero-lateral portion of the tergum and inserted into the antero-lateral portion of the sternal region is found on each side. (Fig. 27, **28, 58**).

5) **Tergo-Pleural Muscles**

On each side there are eight muscles: Four ordinary tergo-pleural muscles (Fig. 27, **29, 30, 31, 32; 59, 60, 61, 62**), two pleuro-axillary muscles (Fig. 27, **33, 34; 63, 64**) and two pleuro-subalar muscles (Fig. 27, **35, 36; 65, 66**).

The first ordinary tergo-pleural muscle (Fig. 27, **29; 59**) is a small bundle arising on the lateral margin of the tergum anterior to the wing base and inserted into the basalare; the second (Fig. 27, **30; 60**) is small, stretching between the antero-lateral corner of the tergum and the basalare externally to the first; the third (Fig. 27, **31; 61**) is a very small muscle arising on the lateral portion of the tergum anterior to the wing base and attached on the dorsal portion of the episternum; the fourth (Fig. 27, **32; 62**) is a muscle arising on the lateral portion of the tergum immediately behind the anterior notal wing process and attached on the pleural arm. The first pleuro-axillary muscle (Fig. 27, **33; 63**) arises on the episternum along the dorsal portion of the pleural ridge by a wide base, the second (Fig. 27, **34; 64**) originates on the epimeron along the dorsal portion of the pleural ridge, both are inserted into the third axillary sclerite. The first pleuro-subalar muscle (Fig. 27, **35; 65**) arises on the pleural arm, the second (Fig. 27, **36; 66**) on the dorso-posterior portion of the epimeron, both are inserted into the subalar sclerite.

6) Sterno-Pleural Muscles

The mesothorax has three sterno-basalar muscles (Fig. 27, **37, 38, 39**) and two furco-entopleural muscles (Fig. 27, **40, 41**) on each side. The first sterno-basalar muscle (Fig. 27, **37**) is small, originated on the lateral intersegmental invagination or the anterior margin of the pleuron under the first thoracic spiracle, the second (Fig. 27, **38**) on the ventro-lateral intersegmental region or anterior margin of the pleuron beneath the first, the third (Fig. 27, **39**) on the antero-lateral portion of the sternal region, all these are inserted into the basalare. The first furco-entopleural muscle (Fig. 27, **40**) is fan-shaped, stretched between the dorsal pleural arm and the furcal arm, the second (Fig. 27, **41**) is very short, stretched between the ventral pleural arm and the furcal arm.

The sterno-pleural muscle in the metathorax (Fig. 27, **67, 68, 69, 70**) resemble those in the mesothorax (Fig. 27, **37, 39, 40, 41**) respectively, but lack the bundle corresponding to the second sterno-basalar muscle in the mesothorax (Fig. 27, **38**).

7) Coxal Muscles and Coxal Wing Muscles

Seven muscles are attached on the base of the coxa as follows: Five coxal muscles—a tergal promotor (Fig. 27, **42**; **71**) arising on the dorso-lateral region of the tergum inside the anterior notal wing process by a wide base and attached on the trochantin at the coxo-trochantinal joint, a sternal promotor (Fig. 27, **43**; **72**) originated on the median ridge of the sternum and attached on the anterior basal marginal thickening of the coxa, a thick tergal remotor (Fig. 27, **44**; **73**) taking its origin on the dorso-lateral portion of the tergum at the outside of the anterior end of the lateral oblique dorsal muscle and its insertion into the meron, a sternal remotor (Fig. 27, **46**; **75**) arising on the furcal arm and inserted into the posterior basicostal ridge of the coxa, a pleural abductor (Fig. 27, **47**; **76**) originated on the lower portion of the episternal region and inserted into the antero-lateral basal rim of the coxa. Two coxal wing muscles—a very thick coxo-subalar muscle (Fig. 27, **45**; **74**) attached dorsally on the invagination of the subalare and ventrally on the lateral portion of the meron,

TABLE XIII

Mecoptera
Panorpidae
Neopanorpa ophthalmica (Fig. 27)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscles)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Median dorsals.	1 (1)
Ventral Muscles.	
Internal longitudinal ventrals.	1 (2)
External ventrals.	1 (3)
Ventral Transverse Muscles.	1 (4)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2 (5) (6)
Anterior internal tergo-sternals.	2 (7) (8)
Posterior tergo-sternals.	1 (9)
Tergo-Pleural Muscles.	
Ordinary tergo-pleurals.	3 (10) (11) (12)
Coxal Muscles.	
Anterior (cervical) sternal promotors.	1 (13)
Ordinary sternal promotors.	1 (14)
Tergal remotors.	2 (15) (16)
Ordinary sternal remotors.	2 (17) (18)
Pleural abductors.	1 (19)
Trochanteral Muscles Arising on the Thorax.	
Pleural depressors.	2 (20) (21)
Sternal depressors.	1 (22)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	1 (23)	1 (53)
Lateral dorsals.	1 (24)	1 (54)
Ventral Muscles.		
Longitudinal ventrals.	1 (25)	1 (55)
Oblique spino-furcal ventrals.	1 (26)	—
Ventral Transverse Muscles.		
Anteriors.	—	1 (56)
Posteriors.	1 (27)	1 (57)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	1 (28)	1 (58)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	4 (29) (30) (31) (32)	4 (59) (60) (61) (62)
Pleuro-axillary muscles.	2 (33) (34)	2 (63) (64)
Pleuro-subalar muscles.	2 (35) (36)	2 (65) (66)
Sterno-Pleural Muscles.		
Sterno-basalar muscles.	3 (37) (38) (39)	2 (67) (68)
Furco-entopleural muscles.	2 (40) (41)	2 (69) (70)
Coxal Muscles and Coxal Wing Muscles.		
Tergal promotors of the coxa.	1 (42)	1 (71)
Ordinary sternal promotors of the coxa.	1 (43)	1 (72)
Tergal remotors of the coxa.	1 (44)	1 (73)
Coxo-subalar muscles.	1 (45)	1 (74)
Ordinary sternal remotors of the coxa.	1 (46)	1 (75)
Pleural abductors of the coxa.	1 (47)	1 (76)
Coxo-basalar muscles.	1 (48)	1 (77)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1 (49)	1 (78)
Trochantero-basalar muscles.	1 (50)	1 (79)
Sternal depressors of the trochanter.	1 (51)	1 (80)
Muscles of the Spiracle.	1 (52)	1 (81)

b) Abdominal Musculature

	I Segment	II Segment	III Segment	VI–VI Segments
Dorsal Muscles.	4 (82)	6 (93)	4(113)	4(130)
	(83)	(94)	(114)	(131)
	(84)	(95)	(115)	(132)
	(85)	(96)	(116)	(133)
		(97)		
		(98)		
Dorsal Transverse Muscles.	—	1 (99)	1(117)	1(135)
Ventral Muscles.	1 (86)	6(100)	5(118)	5(135)
		(101)	(119)	(136)
		(102)	(120)	(137)
		(103)	(121)	(138)
		(104)	(122)	(139)
		(105)		
Ventral Transverse Muscles.	1 (87)	1(106)	1(123)	1(140)
Tergo-Sternal Muscles.	2 (88)	3(107)	3(124)	2(141)
	(89)	(108)	(125)	(142)
		(109)	(129)	
Occlusor of the Spiracle.	1 (90)	1(110)	1(127)	1(143)
Dorsal Dilators of the Spiracle.	1 (91)	1(111)	1(123)	1(144)
Ventral Dilators of Spiracle.	1 (92)	1(113)	1(129)	1(145)

and a coxo-basalar muscle (Fig. 27, **48**; **77**) taking its rise on the basalare and its insertion into the antero-lateral basal rim of the coxa.

8) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

Each segment has three muscles stretched between the thoracic body and the trochanter on each side: A very thick tergal depressor of the trochanter (Fig. 27, **49**; **78**) arising on the dorso-lateral region of the tergum inside the wing base, a slender trochantero-basalar muscle (Fig. 27, **50**; **79**) arising on the basalare, a sternal depressor of the trochanter (Fig. 27, **51**; **80**) taking its rise on the furcal arm, all these attach on the common depressor apodeme of the ventral end of the trochanter.

9) Muscles of the Spiracles

Each thoracic spiracle has a very small occlusor (Fig. 27, **52**; **81**) arising on the lateral intersegmental ridge and attached on the under side of the spiracle.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 27 and Table XIII.

13. TRICHOPTERA

Stenopsychidae. *Stenopsyche griseipennis* MACLACHLAN (Fig. 28)

a. Prothoracic Musculature

1) Dorsal Muscles

The prothorax has three lateral dorsal muscles and an anterior dorsal muscle on each side. The first lateral dorsal muscle (Fig. 28, 1) is short, arising on the middle of the dorso-lateral region of the tergum along the transverse tergal ridge, and the second (Fig. 28, 2) is longer than the first, originating on the antero-lateral portion of the tergum, the third (Fig. 28, 3) is the longest of three, arising on the dorso-lateral portion of the posterior margin of the head, and all these attach on the antero-lateral elongation of the mesotergum. The anterior dorsal muscle (Fig. 28, 4) is oblique, taking its origin on the dorso-lateral portion of the posterior margin of the head and its insertion into the median portion of the tergum immediately behind the transverse tergal ridge.

2) Ventral Muscles

The ventral muscles are two-paired, the first pair (Fig. 28, 5) are internals, fan-shaped, attached anteriorly on the ventro-lateral portions of the posterior margin of the head by small tendons and posteriorly on the furcal arms by wide bases, the second pair (Fig. 28, 6) are externals, originating on the insides of the posterior portions of the ventro-lateral cervical sclerites and inserted into the furcal arms.

3) Ventral Transverse Muscle

A pair of ventral transverse muscles (Fig. 28, 7) arise on the furcal arms of both sides and attach on the median apophysis of the intersegmental membrane between the pro- and mesosternum.

4) Tergo-Sternal Muscles

Seven tergo-sternal muscles are found on each side: Two anterior intersegmental tergo-sternal muscles, one (Fig. 28, 8) arising on the dorsal portion of the posterior end of the head near the dor-

sal median line and inserted into the posterior portion of the ventro-lateral cervical sclerite, the other (Fig. 28, **9**) taking its origin on the dorso-lateral portion of the posterior end of the head and its insertion into the furcal arm; four anterior internal tergo-sternal muscles, the first Fig. 28, **10**) stretched between the antero-lateral corner of the tergum and the anterior end of the ventro-lateral cervical sclerite, the second (Fig. 28, **11**) originating on the antero-lateral corner of the tergum and attached on the middle of the inner portion of the ventro-lateral cervical sclerite, the third (Fig. 28, **12**) arising on the middle of the dorso-lateral region of the tergum and inserted into the ventro-lateral cervical sclerite as the second, the fourth (Fig. 28, **13**) taking its rise on the mesoprealare and its insertion into the ventro-lateral cervical sclerite as the two preceding ones; a posterior tergosternal muscle (Fig. 28, **14**) stretched between the mesoprealare and the profurcal arm.

5) **Tergo-Pleural Muscles**

The tergo-pleural muscles are three-paired: A pair of anterior intersegmental muscles (Fig. 28, **15**) arising on the dorso-lateral portions of the posterior end of the head and attached on the antero-dorsal portions of the episterna; two pairs of ordinary tergo-pleural muscles, one (Fig. 28, **16**) attached dorsally on the median portion of the tergum before the tergal transverse ridge and ventrally on the dorsal marginal portions of the episterna, the other (Fig. 28, **17**) very short, arising on the middle portions of the dorso-lateral regions of the tergum and attached on the dorsal portions of the epimera.

6) **Coxal Muscles**

Each coxa has eight muscles arising on the thorax: Two sternal promotors, one (Fig. 28, **18**) arising on the median ridge of the main sternite by a wide base and inserted into the anterior basal rim of the coxa, the other (Fig. 28, **19**) on the furcal arm and into the anterior basal rim of the coxa as the former; a tergal remotor (Fig. 28, **20**) on the middle of the dorso-lateral region of the tergum immediately anterior to the transverse tergal ridge and into the posterior basal rim of the coxa; a pleural remotor (Fig. 28, **21**) on the

dorsal portion of the epimeron and into the posterior basal rim of the coxa; a posterior spinal remotor (Fig. 28, **22**) on the spina between the pro- and mesosternum and into the posterior basal rim of the coxa; an ordinary sternal remotor (Fig. 28, **23**) on the furcal arm and into the posterior coxal basal rim; two thick pleural abductors (Fig. 28, **24, 25**) on the dorsal portion of the episternum and into the antero-lateral basal rim of the coxa.

7) Trochanteral Muscles Arising on the Thorax

The trochanter has a pleural depressor arising on the pleural arm and attached on the common trochanteral depressor apodeme (Fig. 28, **26**).

b. Pterothoracic Musculature

1) Dorsal Muscles

Three dorsal muscles are found on each side: A thick median internal longitudinal muscle (Fig. 28, **27**; **55**) stretched between both ends of the tergum, a slender median external muscle (Fig. 28, **28, 56**) arising on the anterior portion of the scutellum by a wide base and inserted into the anterior median portion of the postnotum by a slender tendon, and a thick lateral oblique muscle (Fig. 28, **29**; **57**) originated on the scutum lateral to the scutellum and inserted into the lateral portion of the posterior end of the tergum.

2) Ventral Muscles

The mesothorax has two pairs of ventral muscles, one pair (Fig. 28, **30**) longitudinal, stretched between the pro- and mesofurcal arms, the other (Fig. 28, **31**) oblique, attached anteriorly on the spina between the pro- and mesosternum and posteriorly on the furcal arms. The metathorax has a pair of longitudinal ventral muscles (Fig. 28, **58**) similar to those in the mesothorax, but lacks the oblique spinofurcal muscles.

3) Ventral Transverse Muscle

On the mesothorax there is an anterior ventral transverse muscle (Fig. 28, **32**) stretched between the latero-ventral intersegmental

membranes, at the anterior end of the segment. The metathorax lacks the ventral transverse muscle.

4) **Tergo-Sternal Muscles**

Each segment has a pair of very thick anterior tergo-sternal muscles (Fig. 28. **33**; **59**) stretched between the antero-lateral regions of the tergum and sternum, and a pair of slender posterior tergo-sternal muscles (Fig. 28, **34**; **60**) attached ventrally on the furcal arms and dorsally on the antero-lateral corners of the following tergum.

5) **Tergo-Pleural Muscles**

Four ordinary tergo-pleural muscles and two pleuro-axillary muscles are found on each side. The first and second ordinary tergo-pleural muscles (Fig. 28, **35, 36**; **61, 62**) are small, arising on the antero-lateral portion of the tergum and attached on the dorsal flexible margin of the episternum, the third (Fig. 28. **37**; **63**) is small, stretching between the antero-lateral portion of the tergum and the pleural wing process externally to the two former, the fourth (Fig. 28, **38**; **64**) is fan-shaped, attached dorsally on the lateral margin behind the second anterior notal wing process, and ventrally on the pleural ridge by a wide base. The first pleuro-axillary muscle (Fig. 28, **39**; **65**) arises on the dorsal portion of the episternum, the secpnd (Fig. 28, **40**; **66**) on the dorsal portion of the epimeron, and both are inserted into the third axillary sclerite.

6) **Sterno-Pleural Muscles**

The mesothorax has a very thick muscle (Fig. 28, **41**) arising on the ventro-lateral sternal region and attached on the dorsal portion of the episternum, and corresponding to the sterno-basalar muscle in other insects, and two furco-entopleural muscles (Fig. 28, **42, 43**) very similar to those in the Mecoptera, on each side. The metathorax is provided with a small anterior tergo-pleural muscle (Fig. 28, **67**) arising on the ventro-lateral intersegmental region beneath the second thoracic spiracle and attached on the anterior margin of the episternum, and a furco-entopleural muscle (Fig. 28, **68**) similar to the mesothoracic ventral furco-entopleural muscle (Fig. 28, **43**), on each side.

7) Pleural Muscles

A pair of small muscles (Fig. 28, **44**; **69**) are attached dorsally on the antero-ventral margins of the episterna and ventrally on the lateral margins of the lateral wings of the anterior ventral region of the segment. These are very similar to the pleural muscles in the Dermaptera.

8) Coxal Muscles and Coxal Wing Muscles

Muscles attached on the basal portion of the coxa are found on each side as follows: Coxal muscles—a tergal promotor (Fig. 28, **45**; **70**) arising on the antero-lateral portion of the tergum behind the anterior tergo-sternal muscle and inserted into the trochantin at the coxo-trochantinal joint; a sternal promotor (Fig. 28, **46**; **71**) on the sternal median ridge and into the anterior basal rim of the coxa; a thick tergal remotor (Fig. 28, **47**; **72**) on the lateral portion of the tergum inside the wing base and into the meron; a sternal remotor (Fig. 28, **49**; **74**) on the furcal arm and into the posterior basicostal ridge of the coxa; a pleurel abductor (Fig. 28, **75**) found on the metathorax, arising on the episternum anterior to the middle portion of the pleural ridge. Two coxal wing muscles—a very thick coxo-subalar muscle (Fig. 28, **48**; **73**) attached dorsally on the subalare and ventrally on the meron lateral to the tergal remotor; a muscle (Fig. 28, **50**; **76**) corresponding to the coxo-basalar muscle in other insects, taking its origin on the dorsal flexible portion of the episternum and its insertion into the antero-lateral basal rim of the coxa.

9) Trochanteral Muscles Arising on the Thorax

Three trochanteral muscles arising on the thorax and attached on the common depressor apodeme of the trochanter are observed on each side: A very thick tergal depressor (Fig. 28, **51**; **77**) arising on the lateral portion of the tergum inside the wing base, a muscle (Fig. 28, **52**; **78**) corresponding to the trochantero-basalar muscle in other insects, originated on the dorso-anterior marginal portion of the episternum, a thick sternal depressor (Fig. 28, **53**; **79**) arising on the sternal median ridge.

TABLE XIV

Trichoptera
Stenopsychidae
Stenopsyche griseipennis (Fig. 28)

(Nonbracketted numerals show the number of muscles; bracketted numerals show the signs used in the figure; "—" shows the absence of muscle)

a) Thoracic Musculature

Prothoracic Musculature	
Dorsal Muscles.	
Lateral dorsals.	3 (1) (2) (3)
Anterior dorsals	1 (4)
Ventral Muscles.	
Internal longitudinal ventrals.	1 (5)
External ventrals.	1 (6)
Ventral Transverse Muscles.	1 (7)
Tergo-Sternal Muscles.	
Anterior intersegmental tergo-sternals.	2 (8) (9)
Anterior internal tergo-sternals.	4 (10) (11) (12) (13)
Posterior tergo-sternals.	1 (14)
Tergo-Pleural Muscles.	
Anterior tergo-pleurals.	1 (15)
Ordinary tergo-pleurals.	2 (16) (17)
Coxal Muscles.	
Ordinary sternal promotors.	2 (18) (19)
Tergal remotors.	1 (20)
Pleural remotors.	1 (21)
Posterior spinal remotors.	1 (22)
Ordinary sternal remotors.	1 (23)
Pleural abductors.	2 (24) (25)
Trochanteral Muscles Arising on the Thorax.	
Pleural depressors.	1 (26)

Pterothoracic Musculature	Meso-thorax	Meta-thorax
Dorsal Muscles.		
Median dorsals.	2 (27) (28)	2 (55) (56)
Lateral dorsals.	1 (29)	1 (59)
Ventral Muscles.		
Longitudinal ventrals.	1 (30)	1 (53)
Oblique spino-furcal ventrals.	1 (31)	—
Ventral Transverse Muscles.		
Anteriors.	1 (32)	—
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	1 (33)	1 (59)
Posterior tergo-sternals.	1 (34)	1 (60)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	4 (35) (36) (37) (38)	4 (61) (62) (63) (64)
Pleuro-axillary muscles.	2 (39) (40)	2 (65) (66)
Sterno-Pleural Muscles.		
Ordinary sterno-pleurals.	—	1 (67)
Sterno-basalar muscles.	1 (41)	—
Furco-entopleural muscles.	2 (42) (43)	1 (63)
Pleural Muscles.	1 (44)	1 (69)
Coxal Muscles, and Coxal Wing Muscles.		
Tergal promotors of the coxa.	1 (45)	1 (70)
Ordinary sternal promotors of the coxa.	1 (46)	1 (71)
Tergal remotors of the coxa.	1 (47)	1 (72)
Coxo-subalar muscles.	1 (48)	1 (73)
Ordinary sternal remotors of the coxa.	1 (49)	1 (74)
Pleural abductors of the coxa.	—	1 (75)
Coxo-basalar muscles.	1 (50)	1 (76)
Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1 (51)	1 (77)
Trochantero-basalar muscles.	1 (52)	1 (78)
Sternal depressors of the trochanter.	1 (53)	1 (79)
Muscles of the Spiracle.	1 (54)	1 (80)

b) Abdominal Musculature

	I Segment	II Segment	III-VI Segment
Dorsal Muscles.	6(81) (82) (83) (84) (85) (86)	5 (92) (93) (94) (65) (96)	5(105) (106) (107) (108) (109)
Dorsal Transverse Muscles.	—	1 (97)	1(110)
Ventral Muscles.	3(87) (38) (89)	4 (98) (99) (100) (101)	2(111) (112)
Tergo-Sternal Muscles.	1(90)	2(102) (103)	1(113)
Occlusors of the Spiracle.	1(91)	1(104)	1(114)

10) Muscles of the Spiracles

Each thoracic spiracle has an occlusor. The occlusor of the first thoracic spiracle (Fig. 28, **54**) arises on the subspiraculare, that of the second thoracic spiracle (Fig. 28, **80**) on the postero-ventral corner of the mesepimeron. All these are inserted into the ventral side of the spiracle.

c. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figure 28 and Table XIV.

14. LEPIDOPTERA

Plutellidae. *Plutella maculipennis* CURTIS (Fig. 29)
Tortricidae. *Adoxophyes privatana* WALKER (Fig. 30)
Papilionidae. *Papilio thaiwanus* ROTHSCHILD (Fig. 31)
Geometridae. *Milionia zonea* MOORE (Fig. 32)
Syntomidae. *Amata lucerna* WILEM (Fig. 33)

a. Prothoracic Musculature

1) Dorsal Muscles

Three kinds of dorsal muscles are found on the prothorax: median, lateral, and anterior dorsal muscles. The median dorsal muscles in *Plutella maculipennis*, *Adoxophyes privatana* and *Papilio thaiwanus* are one-paired; those in the first species (Fig. 29, **1**) are

long, arising on the posterior end of the head and attached on the first phragmata, near the dorsal median line; those in the two others (Fig. 30, **1**; Fig. 31, **1**) are short, arising on the anterior ends of the dorso-lateral regions of the tergum and inserted into the first phragmata. The median dorsal muscles in *Milionia zonea* and *Amata lucerna* are two-paired, internal and external; the internal pair are muscles (Fig. 32, **1**; Fig. 33, **1**) very similar to the median dorsal muscles in the *Plutella*, the external pair are muscles (Fig. 32, **2**; Fig. 33, **2**) shorter than the internal muscles, arising on the antero-lateral portion (*Milionia*) or the antero-median portions of the tergum (*Amata*) and attached to the first phragmata.

The lateral dorsal muscles in the *Plutella* and *Milionia* are one-paired, those in the former species (Fig. 29, **2**) arise on the anterior portions of the dorso-lateral regions of the tergum, those in the latter species (Fig. 32, **3**) on the middle of the median region of the tergum by wide bases; all these muscles are attached to the antero-lateral corners of the mesoterga. The lateral dorsal muscles in the *Adoxophyes* are two-paired, the first pair are long internal muscles (Fig. 30, **2**) arising on the dorso-lateral portions of the posterior end of the head, the second pair are short external muscles (Fig. 30, **3**) originating on the antero-median region of the tergum, and both pairs are inserted into the antero-lateral corners of the mesotergum. The lateral dorsal muscles in the *Papilio* and *Amata* are three-paired: One pair of internal muscles (Fig. 29, **2**; Fig. 33, **3**) similar to those in the *Adoxophyes;* two pairs of external muscles, the first pair in the *Papilio* (Fig. 31, **3**) arise on the median apodeme of the anterior portion of the tergum and are inserted into the lateral portions of the anterior end of the mesotergum, the first pair in the *Amata* (Fig. 33, **4**) on the antero-lateral portions of the tergum and into the antero-lateral corners of the mesotergum, the second pair in both species (Fig. 31, **4**; Fig. 33, **5**) are similar to the lateral dorsal muscles in the *Milionia.*

The anterior dorsal muscles in the *Plutella* (Fig. 29, **3**), *Adoxophyes* (Fig. 30, **4**) and *Milionia* (Fig. 32, **4**) are one-paired, attached

anteriorly on the dorso-lateral portions of the posterior end of the head, and posteriorly on the anterior end of the median region of the tergum. The anterior dorsal muscles in the *Papilio* (Fig. 31, **5, 6**) and *Amata* (Fig. 33, **6, 7**) are twe-paired, the first pair are very similar to the anterior dorsal muscles in the *Plutella*, *Adoxophyes* and *Milionia*, the second arise on the dorso-lateral portions of the posterior end of the head and are attached to the middle of the median region of the tergum.

2) Ventral Muscles

In the ventral muscles there are three kinds: Long longitudinal muscles arising on the ventro-lateral portions of the posterior end of the head and attached on the furcal arms, longitudinal cervico-furcal (ordinary external ventral) muscles arising on the lateral portions of the ventral cervical sclerite (these portions correspond to the regions called ventro-lateral cervical sclerite in other orders) and inserted into the furcal arms, and very slender sterno-furcal (median external ventral) muscles arising on a small anterior median apophysis of the main sternite and attached on the furcal arms; the cervico-furcal and sterno-furcal muscles are external to the long longitudinal muscles in their situations, in many cases.

The *Plutella* (Fig. 29, **4, 5**) has a pair of long longitudinal ventral muscles, and a pair of longitudinal cervico-furcal muscles arising on the middle portions of the lateral regions of the ventral cervical sclerite. The *Adoxophyes* (Fig. 30, **5, 6, 7**), *Milionia* (Fig. **5, 6, 7**) and *Amata* (Fig. 33, **8, 9, 10**) have a pair of long longitudinal ventral muscles, a pair of longitudinal cervico-furcal muscles similar to those of the *Plutella*, and a pair of longitudinal cervico-furcal muscles arising on the latero-posterior portions of the ventral cervical sclerite. The *Papilio* (Fig. 31, **7, 8, 9, 10**) has three pairs of ventral muscles similar to the ventral muscles in the *Adoxophyes*, *Milionia* and *Amata*, and a pair of sterno-furcal ventral muscles.

3) Ventral Transverse Muscles

The five species (Fig. 29, **6**; Fig. 30, **8**; Fig. 31, **11**; Fig. 32, **8**;

Fig. 33, **11**) have a pair of ventral transverse muscles arising on the furcal arms and attached on the spina at the median posterior end of the sternum.

4) **Tergo-Sternal Muscles**

The tergo-sternal muscles are divided into three kinds, anterior intersegmental tergo-sternals, anterior internal tergo-sternals and posterior tergo-sternals.

The anterior intersegmental tergo-sternal muscles in the *Plutella* (Fig. 29, **7, 8**) are two-paired, one pair arising on the dorso-lateral portions of the posterior end of the head and inserted into the latero-posterior portions of the ventral cervical sclerite, the other on the dorso-lateral portions of the posterior end of the head and into the furcal arms. The *Adoxophyes* has two pairs of anterior intersegmental tergo-sternals, one pair (Fig. 30, **9**) arising on the dorso-lateral portions of the posterior end of the head and inserted into the middle portions of the lateral regions of the ventral cervical sclerite, the other (Fig. 30, **10**) on the posterior median portions of the head and into the latero-posterior portions of the ventral cervical sclerite, but lacks the muscles corresponding to the second anterior intersegmental tergo-sternals in the *Plutella.* The *Papilio* (Fig. 31, **12, 13, 14**), *Milionia* (Fig. 32, **9, 10, 11**) and *Amata* (Fig. 33, **12, 13, 14**) have three pairs of anterior intersegmental tergo-sternal muscles, the first and second pairs are similar to those in the *Adoxophyes*, and the third pair resemble the second anterior interseg-mental tergo-sternal mnscles in the *Plutella.*

The anterior internal tergo-sternal muscles in the *Plutella* are two-paired, one pair (Fig. 29, **9**) arising on the antero-lateral portions of the tergum and inserted into the lateral portions of the ventral cervical sclerite, the other (Fig. 29 **10**) on the first phragmata near the antero-lateral corners of the mesotergum and into the ventral cervical sclerite as the first. The anterior internal tergo-sternal muscles in the *Adoxophyes* (Fig. 30, **11**), *Papilio* (Fig. 31, **15**), *Milionia* (Fig. 32, **12**) and *Amata* (Fig. 33, **15**) are one-paired and, although those in the *Milionia* attach ventrally on the bases of the posterior

tentorial arms, similar to the first anterior internal tergo-sternal muscles in the *Plutella*.

The posterior tergo-sternal muscles in the five species (Fig. 29, **11**; Fig. 30, **12**; Fig. 31, **16**; Fig. 32, **13**; Fig. 33, **16**) are one-paired, and are stretched between the antero-lateral corners of the mesoterga and the profurcal arms.

5) Tergo-Pleural Muscles

The *Adoxophyes* (Fig. 30, **13, 14**), *Papilio* (Fig. 31, **17, 18**) and *Milionia* (Fig. 32, **14, 15**) have two ordinary tergo-pleural muscles on each side, a small bundle arising on the antero-lateral portion of the tergum and inserted into the pleural ridge, a longer bundle on the middle portion of the lateral margin of the median narrow tergite and into the pleural ridge. The *Amata* has a pair of ordinary tergo-pleural muscles (Fig. 33, **17**) very similar to the second ordinary tergo-pleural muscles in the *Adoxophyes, Papilio* and *Milionia.* The *Plutella* lacks the tergo-pleural muscles.

6) Coxal Muscles

(a) Sternal Promotors of the Coxae

Two kinds of sternal promotors are observed in the prothorax, anterior sternal promotors and ordinary sternal promotors. The anterior sternal promotors in the *Plutella* (Fig. 29, **12**), *Adoxophyes* (Fig. 30, **15**), *Papilio* (Fig. 31, **19**), *Milionia* (Fig. 32, **16**) and *Amata* (Fig. 33, **18**) are one-paired, those in the first two species arise on the posterior margins of the ventral cervical sclerites, those in the last three species take their origins on the tentorial bodies, and all the muscles are attached to the anterior basal rims of the coxae.

The ordinary sternal promotors are one-paired in the *Plutella* (Fig. 29, **13**), *Milionia* (Fig. 32, **17**) and *Amata* (Fig. 33, **19**), and two-paired in the *Adoxophyes* (Fig. 30, **16, 17**) and *Papilio* (Fig. 31, **20, 21**);. those in the first species arise on the furcal arms; those in the sceond and third species on the median ridges of the sterna; in the last two species, the first ordinary sternal promotors arise on the anterior median apophysis of the main sternite, the second on the

bases of the furcal arms; all these muscles are attached to the anterior basal rims of the coxae.

(*b*) *Tergal Remotors of the Coxae*

The *Papilio* (Fig. 32, **22**), *Milionia* (Fig. 31, **18**) and *Amata* (Fig. 33, **20**) have a slender tergal remotor arising on the middle portion of the lateral margin of the median narrowed tergite or on the posterior side of the dorso-lateral region of the anterior transverse tergite (*Papilio*) and inserted into the posterior basal rim of the coxa, on each side. The *Plutella* and *Adoxophyes* lack it.

(*c*) *Pleural Remotors of the Coxae*

Each coxa in the *Plutella* (Fig. 29, **14**), *Adoxophyes* (Fig. 30, **18**), *Papilio* (Fig. 31, **23**), and *Amata* (Fig. 33, **21**) has a pleural remotor, that in the *Milionia* (Fig. 32, **19, 20**) has two pleural remotors, all the muscles are slender, originating on the epimera and inserted into the posterior basal rims of the coxae.

(*d*) *Sternal Remotors of the Coxae*

The sternal remotors are divided into two kinds, posterior spinal remotors arising on the spina at the posterior end of the sternum and inserted into the posterior basal rims of the coxae, and ordinary sternal remotors on the furcal arms and into the posterior basal rims of the coxae. The posterior spinal remotors are one-paired in the *Plutella* (Fig. 29, **15**), *Adoxophyes* (Fig. 30, **19**), *Milionia* (Fig. 32, **21**) and *Amata* (Fig. 33, **22**), but lack in the *Papilio*. The ordinary sternal remotors are found in one pair on the *Plutella* (Fig. 29, **16**), *Papilio* (Fig. 31, **24**) and *Milionia* (Fig. 32, **22**), but lack in the *Adoxophyes* and *Amata*.

(*e*) *Pleural Abductors of the Coxae.*

The *Plutella* (Fig. 29, **17, 18**) and *Amata* (Fig. 33, **23, 24**) have two strong pleural abductors, and the *Adoxophyes* (Fig. 30, **20**), *Papilio* (Fig. 31, **25**) and *Milionia* (Fig. 32, **23**) have a thick pleural abductor, on each coxa. The pleural abductors arise on the dorsal portions of the episterna by wide bases and are inserted into the antero-lateral basal rims of the coxae.

7) Trochanteral Muscles Arising on the Thorax

The trochanteral muscles are found in one pair on the *Plutella* (Fig. 29, **19**), *Adoxophyes* (Fig. 30, **21**), *Papilio* (Fig. 31, **26**), *Milionia* (Fig. 32, **24**) and *Amata* (Fig. 33, **25**), these are depressors arising on the lower sides of the pleural arms and attached on the common depressor apodemes of the ventral bases of the trochanters.

b. Mesothoracic Musculature

1) Dorsal Muscles

The *Plutella* (Fig. 29, **20, 21**), *Adoxophyes* (Fig. 30, **22, 23**) and *Amata* (Fig. 33, **26, 27**) have two dorsal muscles on each side, a thick median longitudinal dorsal muscle arising on the anterior portions of the tergum and inserted into the third phragma at the posterior end of the tergum, a lateral oblique dorsal muscle on the posterior portion of the dorso-lateral region of the scutum and into the postero-lateral portion of the postnotum. The *Papilio* (Fig. 31, **27, 28, 29**) and *Milionia* (Fig. 32, **25, 26, 27**) have three dorsal muscles on each side, a thick median dorsal muscle, a short median external dorsal muscle arising on the anterior end of the scutellum and inserted into the postnotum near the dorsal median line, and a lateral oblique dorsal muscle; the first and the last muscle are very similar to the median longitudinal and the lateral oblique dorsal muscle in the *Plutella* respectively.

2) Ventral Muscles

The ventral muscles are two-paired in the five species (Fig. 29, **22, 23**; Fig. 30, **24, 25**; Fig. 31, **30, 31**; Fig. 32, **28, 29**; Fig. 33, **28, 29**): One pair of longitudinal ventral muscles stretched between the profurcal and the mesofurcal arms, and one pair of slender spino-furcal ventral muscles arising on the spina at the anterior end of the sternum and attached on the mesofurcal arms.

3) Tergo-Sternal Muscles

The *Plutella* (Fig. 29, **24, 25**), *Adoxophyes* (Fig. 30, **26, 27**) and *Amata* (Fig. 33, **30, 31**) have a very thick anterior tergo-sternal

muscle attached dorsally on the antero-lateral portion of the tergum and ventrally on the sternum lateral to the sternal median ridge, and a slender posterior tergo-sternal muscle arising on the antero-lateral corner of the metatergum and inserted into the mesofurcal arm, on each side. The *Papilio* (Fig. 31, **32, 33**) has two thick anterior tergo-sternal muscles, and the *Milionia* (Fig. 32, **30**) has a thick anterior tergo-sternal muscle, on each side; their attached positions resemble those of the anterior tergo-sternal muscles in the *Plutella*.

4) **Tergo-Pleural Muscles**

The tergo-pleural muscles divide into three kinds: Ordinary tergo-pleural muscles, pleuro-axillary muscles, and pleuro-subalar muscles. The ordinary tergo-pleural muscles in the *Plutella* (Fig. 29, **26, 27, 28**), *Adoxophyes* (Fig. 30, **28, 29, 30**), *Milionia* (Fig. 32, **31, 32, 33**) and *Amata* (Fig. 33, **32, 33, 34**) are three-paired, the first pair arise on the lateral marginal portions of the tergum before the anterisr notal wing processes, and are inserted into the anterior margins of the upper episternal regions, the second on the antero-lateral corners of the tergum and into the antero-dorsal margins of the upper episternal regions, the third on the lateral margins of the tergum hehind the anterior notal wing processes, and into the middle portions of the pleural ridges. The ordinary tergo-pleural muscles in the *Papilio* (Fig. 31, **34, 35**) are two-paired, the first pair originate on the antero-lateral corners of the tergum and are inserted into the basalar sclerites, and second on the prealar sclerites and into the invaginations of the apices of the pleural wing processes.

The pleuro-axillary muscles in the five species (Fig. 29, **29, 30**; Fig. 30, **31, 32**; Fig. 31, **36, 37**; Fig. 32, **34, 35**; Fig. 33, **35, 36**) are two-paired, the first pair arise on the upper episternal regions or on the lower portions of the episterna (*Papilio*) by wide bases and are attached on the third axillary sclerites, the second pair ventrally on the upper portions of the epimera along the pleural ridges dorsally on the third axillary sclerites.

The pleuro-subalar muscles are found in one bundle on each

side of the five species (Fig. 29, **31**; Fig. 30, **33**; Fig. 31, **38**; Fig. 32, **36**; Fig. 33, **37**); this bundle arises on the posterior portion of the subalare and is attached on the posterior portion of the epimeron.

5) Sterno-Pleural Muscles

In the sterno-pleural muscles there are two kinds: One is sterno-basalar muscles which are one-paired in the *Plutella* (Fig. 29, **32**), *Adoxophyes* (Fig. 30, **34**), *Papilio* (Fig. 31, **39**) and *Amata* (Fig. 33, **38**) and two-paired in the *Milionia* (Fig. 32, **37, 38**), arising on the lateral wings of the anterior sternal region or on the ventral intersegmental region between the pro- and mesothorax and inserted into the basalar sclerites or on the upper maginal portions of the episterna; the other furco-entopleural muscles which are found in one pair on the *Plutella* (Fig. 29, **33**), *Adoxophyes* (Fig. 30, **35**), *Papilio* (Fig. 31, **40**), *Milionia* (Fig. 32, **39**), and *Amata* (Fig. 33, **39**), and stretched between the furcal arms and the pleural ridges.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The *Plutella* (Fig. 29, **34**), *Adoxophyes* (Fig. 30, **36**) and *Milionia* (Fig. 32, **40**) have a tergal promotor arising on the lateral region of the tergum at the anterior inner side of the anterior notal wing process by a wide base, and attached to the anterior basal rim of the coxa, on each side. The *Papilio* (Fig. 31, **41, 42**) and *Amata* (Fig. 33, **40, 41**) have two tergal promotors on each side, an anterior and a posterior. The anterior tergal promotor resembles the tergal promotor in the *Plutella;* the posterior tergal promotor arises on the lateral region of the tergum behind the anterior notal wing process, and is attached to the anterior basal rim of the coxa as the anterior muscle.

(*b*) *Sternal Promotors of the Coxae*

The five species have an ordinary sternal promotor arising on the base of the furca and inserted into the anterior basal rim of the coxa, on each side (Fig. 29, **35**; Fig. 30, **37**; Fig. 31, **43**; Fig. 32, **41**; Fig. 33, **42**).

(c) Tergal Remotors of the Coxae

The coxa in the *Plutella* (Fig. 29, **36**), *Adoxophyes* (Fig. 30, **38**) and *Milionia* (Fig. 32, **42**) have a thick tergal remotor arising on the dorso-lateral region of the tergum at the posterior inner side of the anterior notal wing process and attached on the meron. The coxa in the *Papilio* (Fig. 31, **44, 45**) and the *Amata* (Fig. 33, **43, 44**) has two tergal remotors; the first remotor in the *Papilio* arises on the lateral marginal portion of the tergum behind the anterior notal wing process, the second on the lateral portion of the tergum behind the first; the first tergal remotor in the *Amata* on the lateral portion of the tergum more posterior than in the first remotor of the *Papilio*, and the second on the dorso-lateral region of the tergum at the posterior inner side of the first; the insertion in each case being into the meron of the coxa.

(d) Coxo-Subalar Muscles

A very thick coxo-subalar muscle stretched between the subalare and the meron of the coxa is found on each side of *Plutella* (Fig. 29, **37**), *Adoxophyes* (Fig. 30, **39**), *Papilio* (Fig. 31, **46**), *Milionia* (Fig. 32, **43**) and *Amata* (Fig. 33, **45**).

(e) Sternal Remotors of the Coxae

The *Plutella* (Fig. 29, **38**), *Adoxophyes* (Fig. **40**), *Papilio* (Fig. 31, **47**) and *Amata* (Fig. 33, **46**) have an ordinary sternal remotor, and the *Milionia* (Fig. 32, **44, 45**) has two ordinary sternal remotors, on each side; each muscle arises on the base of the furcal arm and is attached to the posterior basicostal ridge of the coxa.

(f) Pleural Abductors of the Coxae and Coxo-Basalar Muscles

The muscles stretched between the pleuron and the antero-lateral basal coxal rim are two-bundled in the *Plutella* (Fig. 29, **39, 40**), *Adoxophyes* (Fig. 30, **41, 42**), *Papilio* (Fig. 31, **48, 49**), *Milionia* (Fig. 32, **46, 47**) and *Amata* (Fig. 33, **47, 48**). The first is a pleural abductor arising on the episternum before the middle portion of the pleural ridge. The second is a muscle corresponding to the coxo-basalar muscle in other insects, arising on the dorsal flexible marginal por-

tion of the episternum by a wide base or on the basalar sclerite (*Papilio*, Fig. 31, **49**).

7) Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles

(a) Tergal Depressors of the Trochanters

The trochanter in the *Plutella* (Fig. 29, **41**), *Adoxophyes* (Fig. 36, **43**) has a thick tergal depressor arising on the middle of the dorso-lateral region of the tergum and inserted into the common depressor apodeme on the ventral base of the trochanter; in the *Papilio* (Fig. 31, **50, 51**), *Milionia* (Fig. 32, **48, 49**) and *Amata* (Fig. 33, **49, 50**) has two tergal depressors, one arising on the inside (*Amata*) or the posterior side of the anterior notal wing process and inserted into the common depressor apodeme of the trochanter, the other on the middle or somewhat posterior portion of the dorso-lateral region of the tergum and into the depressor apodeme.

(b) Trochantero-Basalar Muscles

The *Plutella* (Fig. 29, **42**), *Adoxophyes* (Fig. 30, **44**), *Papilio* (Fig. 31, **52**), *Milionia* (Fig. 32, **50**) and *Amata* (Fig. 33, **51**) have a muscle corresponding to the trochantero-basalar muscle of other insects on each side. The muscle in the species except the *Papilio* arises on the upper flexible marginal portion of the episternum and attaches to the common depressor apodeme of the trochanter. The muscle in the *Papilio* takes its origin on the free movable basalare and is attached to the common depressor apodeme of the trochanter.

(c) Sternal Depressors of the Trochanters

The five species (Fig. 29, **43**; Fig. 30, **45**; Fig. 31, **53**; Fig. 32, **51**; Fig. 33, **52**) have a pair of sternal depressors very similar to those in the prothorax.

8) Muscles of the Spiracles

The first thoracic spiracle in the *Plutella* (Fig. 29, **44**), *Adoxophyes* (Fig. 30, **46**), *Papilio* (Fig. 31, **54**), *Milionia* (Fig. 32, **52**) and *Amata* (Fig. 33, **53**) has an occlusor arising on the ventral side of

the spiracle and attached on the anterior closing lever. This musculature seems to be a remarkable character in the Lepidoptera.

c. Metathoracic Musculature

1) Dorsal Muscles

The dorsal muscles in the *Plutella* (Fig. 29, **45, 46**), *Adoxophyes* (Fig. 30, **47, 48**), *Papilio* (Fig. 31, **55, 56**), *Milionia* (Fig. 32, **53, 54**) and *Amata* (Fig. 33, **54, 55**) are similar to the mesothoracic dorsal muscles in the *Plutella* (Fig. 29, **20, 21**), *Adoxophyes* (Fig. 30, **22, 23**), etc.

2) Ventral Muscles

The *Plutella* (Fig. 29, **47**), *Adoxophyes* (Fig. 30, **49**), *Papilio* (Fig. 31, **57**) have a pair of longitudinal ventral muscles, the *Milionia* (Fig. 32, **55, 56**) and *Amata* (Fig. 33, **56, 57**) have two pairs of longitudinal ventral muscles, all these muscles are stretched between the meso- and metafurcae.

3) Tergo-Sternal Muscles

In the tergo-sternal muscles there are two kinds, anterior and posterior. The anterior tergo-sternal muscles are found in one pair on the five species (Fig. 29, **48**; Fig. 30, **50**; Fig. 31, **58**; Fig. 32, **57**; Fig. 33, **58**), and resemble their mesothoracic anterior tergo-sternal muscles, except the metathoracic anterior tergo-sternal muscles in the *Papilio* are one-paired. The posterior tergo-sternal muscles are found on the *Plutella* (Fig. 29, **49**) and *Adoxophyes* (Fig. 30, **51**), and are similar to those in their mesothoracics. The *Papilio*, *Milionia* and *Amata* lack the posterior tergo-sternal muscles.

4) Tergo-Pleural Muscles

Two kinds of muscles are found, ordinary tergo-pleural muscles and pleuro-axillary muscles. The ordinary tergo-pleural muscles in the *Plutella* (Fig. 29, **50, 51, 52**) and *Papilio* (Fig. 31, **59, 60, 61**) are three-paired, those in the *Adoxophyes* (Fig. 30, **52, 53**), *Milionia* (Fig. 32, **58, 59**) and *Amata* (Fig. 33, **59, 60**) are two-paired. The first

pair in the *Plutella* (Fig. 29, **50**), *Adoxophyes* (Fig. 30, **52**), *Milionia* (Fig. 32, **58**) and *Amata* (Fig. 33, **53**), the first and second pairs in the *Papilio* (Fig. 31, **59, 60**) are slender; they arise on the antero-lateral corners of the terga and are attached to the dorsal portions of the pleural ridges. The second pair (Fig. 29, **51**) in the *Plutella* and the third pair in the *Papilio* (Fig. 31, **61**) arise on the anterior notal wing processes and are attached to the middle portions of the pleural ridges. The third pair in the *Plutella* (Fig. 29, **52**), the second pair in the *Adoxophyes* (Fig. 30, **53**), *Milionia* (Fig. 32, **59**) and *Amata* (Fig. 33, **60**) arise on the lateral regions of the terga behind the anterior notal wing processes are attached to the middle portions of the pleural ridges.

The pleuro-axillary muscles in the five species (Fig. 29, **53, 54**; Fig. 30, **54, 55**; Fig. 31, **62, 63**; Fig. 32, **60, 61, 62**; Fig. 33, **61, 62**) are similar to their mesothoracic pleuro-axillary ones respectively, except that a pair of muscles (Fig. 32, **62**) arising on the dorsal portions of the pleural ridges and attached on the third axillary sclerites are added to the metathorax of the *Milionia*.

5) **Sterno-Pleural Muscles**

There are sterno-basalar muscles and furco-entopleural muscles as in the mesothorax. The sterno-basalar muscles are two-paired, the first pair in the *Plutella* (Fig. 29, **55**), *Papilio* (Fig. 31, **64**), *Milionia* (Fig. 32, **63**) and *Amata* (Fig. 33, **63**) arise on the ventro-lateral intersegmental regions between the meso- and metathorax near the postero-ventral corners of the mesepimera, the first pair in the *Adoxophyes* (Fig. 30, **56**) on the mesothoracic furcal arms, the second pair in the *Plutella* (Fig. 29, **56**) on the ventral intersegmental membrane between the meso- and metathorax, the second pair in the *Adoxophyes* (Fig. 30, **57**), *Papilio* (Fig. 31, **65**), *Milionia* (Fig. 32, **64**) and *Amata* (Fig. 33, **64**) on the lateral wings of the anterior sternal region, and all these attach on the basalar sclerites.

The furco-entopleural muscles in the five species (Fig. 29, **57**; Fig. 30, **58**; Fig. 31, **66**; Fig. 32, **65**; Fig. 33, **65**) are similar to those

in their mesothorax, but the pleural attached positions of those in the *Papilio* (Fig. 31, **66**), *Milionia* (Fig. 32, **65**) and *Amata* (Fig. 33, **65**) are lower than those in their mesothorax.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors (Fig. 29, **58**; Fig 30, **59**; Fig. 31, **67**; Fig. 32, **66**; Fig. 33, **66**) are one-paired, arise on the antero-lateral portions of the tergum inside the anterior notal wing processes, and attach on the anterior basal rims of the coxae.

(*b*) *Sternal Promotors of the Coxae*

The coxa in the *Adoxophyes* (Fig. 30, **60**), *Papilio* (Fig. 31, **68**), *Milionia* (Fig. 32, **67**) and *Amata* (Fig. 33, **67**) has a sternal promotor similar to their mesothoracic sternal promotor, but in the *Plutella* the muscle is lacking.

(*c*) *Tergal Remotors of the Coxae*

The tergal remotors (Fig. 29, **59**; Fig. 30, **61**; Fig. 31, **69**; Fig. 32, **68**; Fig. 33, **68**) are two-paired and similar to the mesothoracic tergal remotors in the *Plutella*, *Adoxophyes*, etc.

(*d*) *Coxo-SubalarMuscles*

The coxo-subalar muscles (Fig. 29, **60**; Fig. 30, **62**; Fig. 31, **70**; Fig. 32, **69**; Fig. 33, **69**) are very similar to the mesothoracic ones.

(*e*) *Sternal Remotors of the Coxae*

The sternal remotors in the *Adoxophyes* (Fig. 30, **63**), *Papilio* (Fig 31, **71**) and *Amata* (Fig. 33, **70**) are one-paired, those in the *Milionia* (Fig. 32, **70, 71**) are two-paired; all these are very similar to those in their mesothorax respectively. The *Plutella* lacks the sternal remotors.

(*f*) *Pleural Abductors of the Coxae and Coxo-Basalar Muscles*

The pleural abductors (Fig. 29, **61**; Fig. 30, **64**; Fig. 31, **72**; Fig. 32, **72**; Fig. 33, **71**) and the coxo-basalar muscles (Fig. 29, **62**; Fig. 30, **65**; Fig. 31, **73**; Fig. 32, **73**; Fig. 33, **72**) in the five species are similar to those in their mesothorax.

TABLE XV

Lepidoptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figures: "—" shows the absence of muscles)

a) *Prothoracic Musculature*

	Plutellidae. *Plutella maculipennis* (Fig. 29)	Tortricidae. *Adoxophyes privatana* (Fig. 30)	Papilionidae. *Papilio thawanus* (Fig. 31)	Geometridae. *Milionia zonea* (Fig. 32)	Sphingidae. *Sphinx convulvoli* (BERLESE, 1909)	Syntomidae. *Amata lucerna* (Fig. 33)
Dorsal Muscles.						
Median dorsals.	1 (1)	1 (1)	1 (1)	2 (1) (2)	4(140) (CX) (CIX) (CXIII)	2 (1) (2)
Lateral dorsals.	1 (2)	2 (2) (3)	3 (2) (3) (4)	1 (3)	3(140a) (CXV) (CXIV)	3 (3) (4) (5)
Anterior dorsals.	1 (3)	1 (4)	2(5) (6)	1 (4)	4(CXXXVI) (CXXXVII) (CXXXV) (CXXXIII)	2 (6) (7)
Ventral Muscles.						
Internal longitudinal ventrals.	1 (4)	1 (5)	1 (7)	1 (5)	1(137)	1 (8)
External ventrals.						
Laterals (ordinary e.x. v.).	1 (5)	2 (6) (7)	2 (8) (9)	2 (6) (7)	2(CXXXI) (135)	2 (9) (10)
Medians.	—	—	1(10)	—	1(CVI)	—
Ventral Transverse Muscles.	1 (6)	1 (8)	1(11)	1 (8)	1(108)	1(11)
Tergo-Sternal Muscles.						
Anterior intersegmental tergo-sternals.	2 (7) (8)	2 (9) (10)	3(12) (13) (14)	3 (9) (10) (11)	2(147) (CXLI)	3(12) (13) (14)
Anterior internal tergo-sternals.	2 (9) (10)	1(11)	1(15)	1(12)	1(CXXXIV)	1(15)
Posterior tergo-sternals.	1(11)	1(12)	1(16)	1(13)	1(112)	1(16)
Tergo-Pleural Muscles.						
Ordinary tergo-pleurals.	—	2(13) (14)	2(17) (18)	2(14) (15)	3(CXVI) (CXVII) (CXVIII)	1(17)
Coxal Muscles.						
Anterior sternal promotors.						
Cervicals.	1(12)	1(15)	—	—	—	—
Tentorials.	-	—	1(19)	1(16)	1(CXLII)	1(18)
Ordinary sternal promotors.	1(13)	2(16) (17)	2(20) (21)	1(17)	1(127)	1(19)
Tergal remotors.	—	—	1(22)	1(18)	—	1(20)
Pleural remotors.	1(14)	1(18)	1(23)	2(19) (20)	1(CXXIII)	1(21)
Posterior spinal remotors.	1(15)	1(19)	—	1(21)	—	1(22)
Ordinary sternal remotors.	1(16)	—	1(24)	1(22)	—	—
Pleural abductors.	2(17) (18)	1(29)	1(25)	1(23)	1(CXXII)	2(23) (24)
Trochanteral Muscles Arising on the Thorax Pleural depressors.	(119)	1(21)	1(26)	1(24)	1	1(25)

b) Mesothoracic

	Plutellidae. *Plutella maculipennis* (Fig. 29)	Tortricidae. *Adoxophyes privatana* (Fig 30)
Dorsal Muscles.		
Median dorsals.	1(20)	1(22)
Lateral dorsals.	1(21)	1(23)
Ventral Muscles.		
Longitudinal ventrals.	1(22)	1(24)
Mesospino-mesofurcal ventrals.	1(23)	1(25)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	1(24)	1(26)
Posterior tergo-sternals.	1(25)	1(27)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	3(26) (27) (28)	3(28) (29) (30)
Pleuro-axillary muscles.	2(29) (30)	2(31) (32)
Pleuro-subalar muscles.	1(31)	1(33)
Sterno-Pleural Muscles.		
Sterno-basalar muscles.	1(32)	1(34)
Furco-entopleural muscles.	1(33	1(35)
Coxal Muscles and Coxal Wing Muscles.		
Tergal promotors of the coxa.	1(34)	1(36)
Ordinary sternal promotors of the coxa.	1(35)	1(37)
Tergal remotors of the coxa.	1(36)	1(38)
Coxo-subalar muscles.	1(37)	1(39)
Ordinary sternal remotors of the coxa.	1(38)	1(40)
Tergal abductors of the coxa.	—	—
Pleural abductors of the coxa.	1(39)	1(39)
Coxo-basalar muscles.	1(40)	1(40)
Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1(41)	1(43)
Trochantero-basalar muscles.	1(42)	1(44)
Sternal depressors of the trochanter.	1(43)	1(45)
Muscles of the Spiracle.	1(44)	1(46)

Musculature

ionidae. *bilio iwanus* Fig. 31)	Papilionidae. *Papilio* sp. (WEBER, 1928)	Geometridae. *Milionia zonea* (Fig. 32)	Sphingidae. *Sphinx convulvoli* (BERLESE, 1909)	Syntomidae. *Amata lucerni* (Fig. 33)
2(27)		2(25)	2(70)	1(26)
(28)		(26)	(69)	
1(29)		1(27)	1(71)	1(27)
1(30)	1(Ivlm1)	1(28)	1(105-106)	1(28)
1(31)	—	1(29)	—	1(29)
2(32)	3(IIdvm1)	1(30)	2(LXXVIII)	1(30)
(33)	(IIdvm2)			
	(IIdvm5)			
—	1(IIism)	—	1(73a)	1(31)
2(34)	1(IIpm3)	3(31)	4(87)	3(32)
(35)		(32)	(XCI)	(33)
		(33)	(LXXVI)	(34)
			(LXXV)	
2(36)	2(IIpm4)	2(34)	2(XCII)	2(35)
(37)	(IIpm5)	(35)	(85)	(36)
1(38)	1(IIpm9)	1(36)	1(CIV)	1(37)
1(39)	1(IIpm1)	2(37)	2(91)	1(38)
		(38)	(91a)	
1(40)	—	1(39)	1(1000)	1(39)
2(41)	1(IIdvm3)	1(40)	2(74)	2(40)
(42)				(41)
1(43)	1(IIbm1)	1(41)		1(42)
2(44)	3(IIdvm8)	1(42)	2(75)	2(43)
(45)				(44)
1(46)	2(IIpm7)	1(43)	1(84)	1(45)
1(47)	1(IIbm3)	2(44)		1(46)
		(45)		
—	1(IIdvm6)	—		—
1(48)	1(IIpm6)	1(46)	1(83)	1(47)
1(49)	1(IIpm2)	1(47)	1(82)	1(48)
2(50)	2(IIdvm4)	2(48)	2(76)	2(46)
(51)	(IIdvm7)	(49)	(76a)	(50)
1(52)	—	1(50)	1(81)	1(51)
1(53)	1(IIbm2)	1(51)		1(52)
1(54)		1(52)		1(53)

c) Metathoracic

	Plutellidae. *Plutella maculipennis* (Fig. 29)	Tortricidae. *Adoxophyes privatana* (Fig. 30)
Dorsal Muscles.		
Median dorsals.	1(45)	1(47)
Lateral dorsals.	1(46)	1(48)
Ventral Muscles.		
Longitudinal ventrals.	1(47)	1(49)
Tergo-Sternal Muscles.		
Anterior tergo-sternals.	1(48)	1(50)
Posterior tergo-sternals.	1(49)	1(51)
Tergo-Pleural Muscles.		
Ordinary tergo-pleurals.	3(50) (51) (52)	2(52) (53)
Pleuro-axillary muscles.	2(53) (54)	2(54) (55)
Sterno-Pleural Muscles.		
Sterno-basalar muscles.	2(55) (56)	2(56) (57)
Furco-entopleural muscles.	1(57)	1(58)
Coxal Muscles snd Coxal Wing Muscles.		
Tergal promotors of the coxa.	1(58)	1(56)
Ordinary sternal promotors of the coxa.	—	1(60)
Tergal remotors of the coxa.	1(59)	1(61)
Coxo-subalar muscles.	1(60)	1(62)
Ordinary sternal remotors of the coxa.	—	1(63)
Pleural abductors of the coxa.	1(61)	1(64)
Coxo-basalar muscles.	1(62)	1(65)
Trochanteral Muscles Arising on the Thorax and Trochanteral Wing Muscles.		
Tergal depressors of the trochanter.	1(63)	1(66)
Trochantero-basalar muscles.	1(64)	1(67)
Sternal depressors of the trochanter.	1(65)	1(68)
Muscles of the Spiracle.	1(66)	1(69)

Musculature

Papilionidae. *Papilio thaiwanus* (Fig. 31)	Papilionidae. *Papilio* sp. (WEBER, 1928)	Geometridae. *Milionia zonea* (Fig. 32)	Sphingidae. *Sphinx convulvoli* (BERLESE, 1909)	Syntomidae. *Amata lucerna* (Fig. 33)
1(55) 1(56)		1(53) 1(54)	2(37) (38a)? 1(38)	1(54) 1(55)
1(57)	2(IIvlm1) (IIvlm2)	2(55) (56)	1(68)	2(56) (57)
1(58) —	1(IIIdvm1) —	1(57) —	1(XXXVI) —	1(58) —
3(59) (60) (61) 2(62) (63)	— 2(IIIpm6) (IIIpm3)	2(58) (59) 3(60) (61) (62)	— 2(56a) (56)	2(59) (60) 2(61) (62)
2(64) (65) 1(66)	— —	2(63) (64) 1(65)	— 1(65)	2(63) (64) 1(65)
1(67) 1(68) 1(69) 1(70) 1(71) 1(72) 1(73)	1(IIIdvm2) 1(IIbm1) 1(IIIdvm4) 2(IIIpm4) (IIIpm5) 1(IIIbm3) 1(IIIbm7) 1(IIIpm1)	1(66) 1(67) 1(68) 1(69) 2(70) (71) 1(72) 1(73)	1(42) 1(43) 1(XLIX) 1(51) 1(XLVII)	1(66) 1(67) 1(68) 1(69) 1(70) 1(71) 1(72)
1(74) 1(75) 1(76)	1(IIIdvm3) 1(IIIpm2) 1(IIIbm2)	1(74) 1(75) 1(76)	1(46)	2(73) (74) 1(75) 1(76)
1(77)		1(77)		1(77)

d) Abdominal Musculature

	Plutellidae. *Plutella maculipennis* (Fig. 29)	Tortricidae. *Adoxophyes privatana* (Fig. 30)	Papilionidae. *Papilio thaiwanus* (Fig. 31)	Geometridae. *Milionia zonea* (Fig. 32)	Syntomidae. *Amata lucerna* (Fig. 33)
I Segment					
Dorsal Muscles.	2 (67) (68)	2 (70) (71)	3 (78) (79) (80)	3 (78) (79) (80)	2 (78) (79)
Ventral Muscles.	2 (69) (70)	2 (72) (73)	1 (81)	2 (81) (82)	2 (80) (81)
Tergo-Sternal Muscles.	2 (71) (72)	1 (74)	1 (82)	—	1 (82)
Occlusor of the Spiracle.	1 (73)	1 (75)	1 (83)	1 (83)	1 (83)
Ventral Dilator of the Spiracle.	1 (74)	—	—	—	1 (84)
Dorsal Dilator of the Spiracle.	—	1 (76)	—	1 (84)	—
II Segment					
Dorsal Muscles.	5 (75) (76) (77) (78) (79)	3 (77) (78) (79)	1 (84)	4 (85) (86) (87) (88)	3 (85) (86) (87)
Dorsal Transverse Muscles.	1 (80)	1 (80)	1 (85)	1 (89)	—
Ventral Muscles.	2 (81) (82)	2 (81) (82)	1 (86)	3 (90) (91) (92)	2 (88) (89)
Ventral Transverse Muscles.	—	—	1 (87)	1 (93)	—
Tergo-Sternal Muscles.	4 (83) (84) (85) (86)	2 (83) (84)	2 (88) (89)	3 (94) (95) (96)	1 (90)
Occlusor of the Spiracle.	1 (87)	1 (85)	1 (90)	1 (97)	1 (91)
Dorsal Dilator of the Spiracle.	—	1 (86)	—	1 (98)	—
III–VI Segments					
Dorsal Muscles.	5 (88) (89) (90) (91) (92)	3 (87) (88) (89)	1 (84)	4 (85) (86) (87) (88)	3 (92) (93) (94)
Dorsal Transverse Muscles.	1 (93)	1 (90)	1 (85)	1 (89)	1 (95)
Ventral Muscles.	4 (94) (95) (96) (97)	2 (91) (92)	1 (86)	3 (90) (91) (92)	3 (96) (97) (98)
Ventral Transverse Muscles.	—	—	1 (87)	1 (93)	—
Tergo-Sternal Muscles.	4 (98) (99) (100) (101)	1 (93)	2 (88) (89)	3 (94) (95) (96)	1 (99)
Occlusor of the Spiracle.	1 (102)	1 (94)	1 (90)	1 (97)	1 (100)
Dorsal Dilator of the Spiracle.	—	1 (95)	—	1 (98)	—

7) Trochanteral Muscles Arising on the Thorax

(*a*) *Tergal Depressors of the Trochanters*

The tergal depressors in the *Plutella* (Fig. 29, **63**), *Adoxophyes* (Fig. 30, **66**), *Papilio* (Fig. 31, **74**) and *Milionia* (Fig. 32, **74**) are one-paired, very similar to the mesothoracic tergal depressors in the *Plutella* and *Adoxophyes;* those in the *Amata* (Fig. 33, **73, 74**) are two-paired, the first pair are internal bundles arising on the middle portions of dorso-lateral regions of the tergum, the second are external bundles arising on the lateral regions of the tergum lateral to the first, both are inserted into the common depressor apodemes of the trochanters.

(*b*) *Trochantero-Basalar Muscles*

The trochantero-basalar muscles are one-paired, attached dorsally on the movable basalar sclerites and ventrally on the common depressor apodemes of the trochanters (Fig. 29, **64**; Fig. 40, **67**; Fig. 31, **75**; Fig. 32, **75**; Fig. 33, **75**).

(*c*) *Sternal Deprrssors of the Trochanters*

The sternal depressors (Fig, 29, **65**; Fig. 30, **68**; Fig. 31, **76**; Fig. 32, **76**; Fig. 33, **76**) are very similar to the mesothoracic ones.

8) Muscles of the Spiracles

The second thoracic spiracle (Fig. 29, **66**; Fig. 30, **69**; Fig. 31, **77**; Fig. 32, **77**; Fig. 33, **77**) has an occlusor arising on the ventro-lateral intersegmental region between the meso- and metathorax, and attached on the ventral side of the spiracle.

The thoracic muscles are tabulated below, including those of some other species observed by other authors.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figs. 29-33 and Table XV.

15. COLEOPTERA

Cicindelidae. *Cicindela kaleea* BATES (Fig. 34)
Carabidae. *Chlaenius naeviger* MORAWITZ (Fig. 35)
Staphylinidae. *Borolinus minutus* CASTERNAU (Fig. 36)
Coccinellidae. *Epilachna vigintioctopunctata* FABRICIUS (Fig. 37)
Tenebrionidae. *Ceropria induta* WIEDEMANN (Fig. 38)
Chrysomelidae. *Rhaphidopalpa femoralis* MOTSCHULSKY (Fig. 39)
Scarabaeidae. *Mimela testaceoviridis* BLANCHARD (Fig. 40)

a. Prothoracic Musculature

1) Dorsal Muscles

Three kinds of dorsal muscles are observed in the Coleoptera: median, lateral, and anterior. The *Cicindella* (Fig. 34, **1, 2**), *Chlaenius* (Fig. 35, **1, 2**), *Borolinus* (Fig. 36, **1, 2**), *Epilachna* (Fig. 37, **1, 2**), and *Rhaphidopalpa* (Fig. 39, **1, 2**) have an internal median dorsal muscle and an external median dorsal muscle, the *Ceropria* (Fig. 38, **1, 2, 3**) has two internal median dorsal muscles and an external median dorsal muscle, and the *Mimela* (Fig. 40, **1**) has a median dorsal muscle, on each side. The internal median dorsal muscle in the first six species (Fig. 34, **1**; Fig. 35, **1**; Fig. 36, **1**; Fig. 37, **1**; Fig. 39, **1**; Fig. 38, **1, 2**) and the median dorsal muscle in the last species (Fig. 40, **1**) are attached anteriorly on the dorsal posterior end of the head and posteriorly on the first phragma by a wide base near the dorsal median line. The external dorsal muscle in the *Cicindella* Fig. 34, **2**), *Chlaenius* (Fig. 35, **2**), *Borolinus* (Fig. 36, **2**), *Epilachna* 37, **2**), *Ceropria* (Fig. 38, **3**) and *Rhaphidopalpa* (Fig. 39, **2**) arises on the anterior median portion of the tergum, and is attached on the first phragma externally to the internal median dorsal muscle.

The lateral dorsal muscles in the *Cicindella* (Fig. 34, **3**), *Chlaenius* (Fig. 35, **3**), *Borolinus* 36, **3**), *Epilachna* Fig. 37, **3**), *Ceropria* (Fig. 38, **4**) and *Rhaphidopalpa* (Fig. 39, **3**) are one-paired, oblique, arising on the posterior portions of the dorso-lateral regions of the tergum by wide bases, and attached on the intersegmental membranes forward the dorsal portions of the mesepisterna; those in the *Mimela* are two-paired, the first pair (Fig. 40, **2**) are very thick, fan-shaped,

arising on the median anterior portions of the tergum by broad bases, and attached to the antero-lateral corners of the mesotergum, the second pair (Fig. 40, **3**) are oblique muscles similar to the lateral dorsal muscles in the first six species.

The anterior dorsal muscles in the *Chlaenius* (Fig. 35, **4**), the *Borolinus* (Fig. 36, **4**), *Epilachna* (Fig. 37, **4**), *Rhaphidopalpa* (Fig. 39, **4**), *Mimela* (Fig. 40, **4**) are one-paired; those in the first four species arise on the middle or somewhat posterior region of the tergum along both sides of the dorsal median line; those in the last species on the posterior portions of the dorso-lateral regions of the tergum by wide bases. All these take the insertion into the dorso-lateral portion of the posterior end of the head. Those in the *Cicindella* (Fig. 34, **4, 5**) are two-paired, one pair are anterior, arising on the anterior median region of the tergum and inserted into the dorso-lateral regions of the posterior end of the head, the other are posterior, and very similar to the anterior dorsal muscles in the *Chlaenius, Borolinus*, etc. The *Ceropria* lacks the anterior dorsal muscles.

2) **Ventral Muscles**

The ventral muscles are divisible into two kinds, internal and external. The internal ventrals are stretched between the head and the profurcal arms; those in the *Cicindella* (Fig. 34, **6, 7**), *Chlaenius* (Fig. 35, **5, 6**), *Epilachna* 37, **5, 6**), *Rhaphidopalpa* (Fig. 39, **5, 6**) are twopaired, those in the *Borolinus* (Fig. 36, **5**), *Ceropria* (Fig. 38, **5**) and *Mimela* (Fig. 40, **5**) are one-paired. The anterior attached positions of the muscles vary as follows: The first internal ventral muscles in the *Cicindella* (Fig. 34, **6**), *Chlaenius* (Fig. 35, **5**), *Epilachna* (Fig. 37, **5**) and *Rhaphidopalpa* (Fig. 39, **5**), and the internal ventral muscle in the *Borolinus* (Fig. 36, **5**) arise on the base of the posterior tentorial arm; the second internal ventral muscles in the *Cicindella* (Fig. 34, **7**), *Chlaenius* (Fig. 35, **6**), *Epilachna* (Fig. 37, **6**) and *Rhaphidopalpa* (Fig. 39, **6**), and the internal ventral muscles in the *Ceropria* (Fig. 38, **5**) and *Mimela* (Fig. 40, **5**) on the ventro-lateral portion of the posterior end of the head.

The external ventrals are muscles stretched between the cervical region and the profurcal arms. The *Borolinus* (Fig. 36, **6**), *Epilachna* (Fig. 37, **7**) and *Mimela* (Fig, 40, **6**) have a pair of external ventral muscles attached anteriorly on the ventro-lateral cervical sclerites. The *Epilachna* (Fig. 37, **8**), *Ceropria* (Fig. 38, **6**) and *Rhaphidopalpa* (Fig. 39, **7**) have a pair of external ventral muscles originating anteriorly on the middle portions of the ventro-lateral regions of the cervicum. The *Cicindella* and *Chlaenius* lack the external ventral muscles.

3) Tergo-Sternal Muscles

In the tergo-sternal muscles are found three kinds, anterior intersegmental, anterior internal, and posterior. The anterior intersegmental tergo-sternal muscles in the *Cicindella* (Fig. 34, **8**), *Chlaeuius* (Fig. 35, **7**), *Ceropria* 38, **7**) and *Rhaphidopalpa* (Fig. 39, **8**) are one-paired, those in the *Borolinus* (Fig. 36, **7, 8**), *Epilachna* (Fig. 37, **9, 10**) and *Mimela* (Fig. 40, **7, 8**) are two-paired. The anterior intersegmental tergo-sternal muscle in the *Cicindella* (Fig. 34, **8**) is thick, arising on the middle portion of the median region of the sternum by a wide base, that in the *Chlaenius* (Fig. 35, **7**) is very slender, originating on the lateral portion of the anterior end of the sternum, that in both takes the insertion into the dorso-lateral portion of the posterior end of the head; that in the *Ceropria* (Fig. 38, **7**) and *Rhaphidopalpa* (Fig. 39, **8**) takes its origin on the antero-lateral portion of the sternum and its insertion into the median portion of the posterior end of of the head. The first anterior intersegmental tergo-sternal muscle in the *Borolinus* (Fig. 36, **7**) and *Epilachna* (Fig. 37, **9**) is attached ventrally on the posterior portion of the ventro-lateral cervical sclerite, that in the *Mimela* (Fig. 40, **7**) on the anterior portion of the ventro-lateral cervical sclerite, the second anterior intersegmental tergo-sternal muscle in these three species (Fig. 33, **8**; Fig. 37, **10**; Fig. 40, **8**) on the antero-lateral portion of the sternum; the first muscle as well as the second is inserted into the dorso-lateral portion of the posterior end of the head.

The anterior internal tergo-sternal muscles in the *Borolinus* (Fig. 36, **9**) are one-paired, arising on the anterior median region of the tergum along the dorsal median ridge by wide bases, and attach to the anterior portions of the ventro-lateral cervical sclerites. The anterior internal tergo-sternal muscles in the *Cicindella* (Fig. 34, **9, 10**), *Epilachna* (Fig. 37, **11, 12**), *Chlaenius* (Fig. 35, **8, 9**), *Rhaphidopalpa* (Fig. 39, **9, 10**) and *Mimela* (Fig. 40, **9, 10**) are two-paired; those in the *Cicindella* arise on the dorso-lateral regions of the tergum, and attach on the ventro-lateral portions of the posterior end of the head; those in the *Epilachna* are similar to those of the *Cicindella*, but take the ventral attached positions on the ventro-lateral cervical sclerites; in the *Chlaenius* and *Rhaphidopalpa* the first or anterior bundles (Fig. 35, **8**; Fig. 39, **9**) arise on the anterior portions of the dorso-lateral regions of the tergum, the second or posterior bundles (Fig. 35, **9**; Fig. 39, **10**) on the lateral portions of the first phragmata, and both are inserted into the ventro-lateral portions of the posterior end of the head; those in the *Mimela* resemble those in the *Chlaenius* and *Rhaphidopalpa*, except that the former attach ventrally on the ventro-lateral cervical sclerites. The anterior internal tergo-sternal muscles in the *Ceropria* are three-paired, the first and second pairs (Fig 38, **8, 9**) are similar to those in the *Cicindella* (Fig, 34, **9, 10**), while the third pair (Fig. 38, **10**) to the second or posterior bundles in the *Chlaenius* (Fig. 35, **9**) and *Rhaphidopalpa* (Fig. 39, **10**).

The posterior tergo-sternal muscles are found in a pair on the seven species (Fig. 34, **11**; Fig. 35, **10**; Fig. 36, **10**; Fig. 37, **13**; Fig. 38, **11**; Fig. 39, **11**; Fig. 40, **11**), very slender, stretched between the antero-lateral corners of the mesotergum and the prothoracic furcal arms.

4) Tergo-Pleural Muscles

The *Chlaenius* (Fig. 35, **11**), *Borolinus* (Fig. 36, **11**), *Epilachna* (Fig. 37, **14**), *Ceropria* (Fig. 38, **12**), *Rhaphidopalpa* (Fig. 39, **12**) and *Mimela* (Fig. 40, **12**) have a tergo-pleural muscle on each side, but the *Cicindella* lacks it. The tergo-pleural muscle in the first, third,

fourth, fifth and sixth species is very short, broad, and stretched between the lateral portion of the tergum and the dorsal marginal portion of the pleuron, that in the second species is oblique, long, arises on the antero-lateral portion of the tergum and attaches on the apodeme of the dorsal portion of the episterno-trochantinal region.

5) **Coxal Muscles**

(*a*) *Tergal Promotors of the Coxae*

The *Cicindella* (Fig. 34, **12, 13**) and *Chlaenius* (Fig. 35, **12, 13**) have two tergal promotors on each coxa, one arising on the antero-lateral portion of the tergum and inserted into the small trochantin, the other on the position somewhat anterior to the middle of the dorso-lateral region of the tergum by a wide base and into the trochantin. The *Borolinus* (Fig.36, **12**), *Epilachna* (Fig. 37, **15**), *Ceropria* (Fig. 38, **13**) and *Rhaphidopalpa* (Fig. 39, **13**) have a tergal promotor arising on the middle or somewhat anterior portion of the tergum and inserted into the apodeme of the anterior basal rim of the coxa, on each side. The *Mimela* lacks the tergal promotor.

(*b*) *Pleural Promotors of the Coxae*

The pleural promotors are one-paired in the *Chlaenius* and *Borolinus*, but are lacking in the others. The pleural promotor in the *Chlaenius* (Fig. 35, **14**) arises on the antero-dorsal portion of the pleuron, and is inserted into the anterior basal rim of the coxa by a tendon, in the *Borolinus* (Fig. 36, **13**) on the apodeme of the dorsal portion of the episterno-trochantinal region and into anterior basal rim of the coxa by a tendon.

(*c*) *Tergal Remotors of the Coxae*

The *Epilachna* (Fig. 37, **16**) and *Rhaphidopalpa* (Fig. 39, **14**) have a very thick fan-shaped tergal remotor arising on the middle (*Rhaphidopalpa*) or posterior (*Epilachna*) portion of the dorso-lateral region of the tergum and inserted into the posterior basal rim of the coxa, on each side. The *Cicindella* (Fig. 34, **14, 15**), *Borolinus* (Fig. 36, **14, 15**), *Ceropria* (Fig. 38, **14, 15**) and *Mimela* (Fig. 40, **13, 14**) are provided with two thick fan-shaped tergal remotors on each side, an inner and

an outer, the inner bundle arises on the about middle portion of the dorso-lateral region of the tergum, the outer bundle on the middle (*Borolinus*) or posterior portion of the lateral region of the tergum, both attach on the posterior basal rim of the coxa. The *Chlaenins* has three very thick fan-shaped tergal remotors (Fig. 35, **15**, **16**, **17**) on the coxa, an inner and two outers, the inner bundle arises on the portion somewhat anterior to the middle of the median region of the tergum, the two others (Fig. 35, **16**, **17**) originate on the middle of the dorso-lateral region of the tergum, all these are inserted into the posterior basal rim of the coxa by a common tendon.

(*d*) *Pleural Remotors of the Coxae*

The pleural remotors are found in one pair on the *Mimela* (Fig. 40, **15**), arising on the dorsal portions of the pleura and attached on the posterior basal rims of the coxae.

(*e*) *Sternal Remotors of the Coxae*

The *Cicindella* (Fig. 34, **16**), *Chlaenius* (Fig. 35, **18**), *Epilachna* (Fig. 37, **17**) and *Rhaphidopalpa* (Fig. 39, **15**) have an ordinary sternal remotor arising on the furcal arm and inserted into the posterior basal rim of the coxa on each side, but the *Borolinus*, *Ceropria* and *Mimela* lack the sternal remotors.

(*f*) *Pleural Abductors of the Coxae*

The Pleural abductors are one-paired in the *Ceropria* (Fig. 38, **16**), *Rhaphidopalpa* (Fig. 39, **16**) and *Mimela* (Fig. 40, **16**), thick, they arise on the dorsal portions of the pleura and are attached to the antero-lateral basal rims of the coxae.

6) Trochanteral Muscles Arising on the Thorax

In the trochanteral muscles there are two kinds, tergal depressors and pleural depressors. The *Cicindella* (Fig. 34, **17**) has a strong tergal depressor arising on the lateral marginal portion of the tergum by a wide base on each side, but the six other species lack the tergal depressors. The *Chlaenius* (Fig. 35, **19**), *Borolinus* (Fig. 36, **16**), *Epilachna* (Fig. 37, **18**), *Rhaphidopalpa* (Fig. 39, **17**) and *Mimela* (Fig. 40, **17**) have a pleural depressor on each side; that in the first species is very thick, arising on the dorsal marginal portion of the pleuron by

a very wide base, in the second on the dorso-posterior portion of the pleuron, in the last three species on the dorsal invagination of the middle portion of the pleuron. The *Ceropria* has three pleural depressors on each side, an internal (Fig. 38, **17**) and two externals (Fig. 38, **18, 19**), the internal bundle is very thick, arising on the dorsal invagination of the middle portion of the pleuron, while the two external bundles originate on the middle portion of the pleuron. All the depressors each take the insertion into the depressor apodeme of the trochanter.

b. Mesothoracic Musculature

1) Dorsal Muscles

The *Cicindella* (Fig. 34, **18**), *Chlaenius* (Fig. 35, **20**), *Borolinus* (Fig. 36, **17**), *Epilachna* (Fig. 17, **19**), *Ceropria* (Fig. 38, **20**), *Rhaphidopalpa* (Fig. 39, **18**) and *Mimela* (Fig. 40, **18**) have a thick median longitudinal dorsal muscle on each side; the median dorsal muscle in the first three species arises on the under side of the unpaired anterior plate-like invagination of which both sides entering the dorso-lateral regions of the tergum, and attaches on the second phragma; that in the last four species is stretched between the first phragma and the second phragma near the dorsal median line. The *Borolinus* (Fig. 36, **18**), *Epilachna* (Fig. 37, **20**), *Ceropria* (Fig. 38, **21**), *Rhaphidopalpa* (Fig. 39, **19**) have a lateral oblique dorsal muscle on each side; the lateral dorsal muscle in the first species arises on the ventral side of the anterior plate-like invagination of the tergum, in the second species on the middle of the dorso-lateral region of the tergum anterior to the transverse ridge dividing the wing bearing tergum into an anterior and a posterior region, in the third species on the antero-median portion of the tergum, in the fourth species on the anterior median ridge of the tergum, all these each take the insertion into the antero-lateral corner of the metatergum.

2) Ventral Muscles

The *Cicindella* (Fig. 34, **19**), *Borolinus* (Fig. 36, **19**), *Epilachna*

(Fig. 37, **21**), *Ceropria* (Fig. 38, **22**), *Rhaphidopalpa* (Fig. 39, **20**) and *Mimela* (Fig. 40, **19**) have a longitudinal ventral muscle stretched between the profurcal and mesofurcal arms, and the *Chlaenius* (Fig. 35, **21, 22**) has a longitudinal ventral muscle similar to that in the six others, and a slender spino-furcal ventral muscle arising on the median apophysis between the pro- and mesosternum and inserted into the mesofurcal arm, on each side.

3) **Tergo-Sternal Muscles**

The *Borolinus* has a pair of special anterior tergo-sternal muscles (Fig. 36, **20**) arising on the postero-lateral portion of the protergum and inserted into the antero-lateral portion of the mesosternum, and a pair of very slender posterior tergo-sternal muscles (Fig. 36, **21**) similar to those in the prothorax, and the *Mimela* has a pair of posterior tergo-sternal muscles (Fig. 40, **20**) similar to those in the *Borolinus*, but the five others lack the mesothoracic tergo-sternal muscles.

4) **Tergo-Pleural Muscles**

In the tergo-pleural muscles there are three kinds, ordinary tergo-pleural muscles, pleuro-axillary muscles, and pleuro-subalar muscles. The ordinary tergo-pleural muscles in the *Chlaenius* (Fig. 35, **23**), *Borolinus* (Fig. 36, **22**), *Epilachna* (Fig, 37 **22**), *Ceropria* (Fig. 38, **23**) and *Rhaphidopalpa* (Fig. 39, **21**) are one-paired, arising on the antero-lateral portions of the tergum and attached on the dorsal portions of the pleural ridges; those in the *Mimela* are two-paired, the first pair (Fig. 40, **21**) are similar to the ordinary tergo-pleural muscles in the five former species, the second (Fig. 40, **22**) are muscles arising on the middle portions of the lateral regions of the tergum and inserted into the dorsal portions of the pleural ridges. The *Cicindella* lacks the ordinary tergo-pleural muscles.

The pleuro-axillary muscles are one-paired in the *Cicindella* (Fig. 34, **20**), *Chlaenius* (Fig. 35, **24**), *Borolinus* (Fig. 36, **23**), *Epilachna* (Fig. 37, **23**), *Rhaphidopalpa* (Fig. 39, **22**) and *Mimela* (Fig. 40, **23**), and those in these species, except that those of the *Borolinus* arise on the ventral portions of the pleural ridges and attach on the axillary plates, take their origins on the dorsal portions of the pleural ridges and their

insertions into the plates corresponding to the third axillaries in the other insects. As far as the writer observed the pleuro-axillary muscles were not fonnd on the *Ceropria.*

The pleuro-subalar muscles are divisible into two kinds by their arisnig positions, ordinary pleuro-subalar or epimero-subalar muscles and episterno-subalar muscles. The epimero-subalar muscles in the *Epilachna* (Fig. 37, **24**), *Ceropria* (Fig. 38, **24**) and *Mimela* (Fig. 40, **24**) are one-paired, those in the *Rhaphidopalpa* (Fig. 39, **23**, **24**) are two-paired, but lacking in the *Cicindella*, *Chlaenius* and *Borolinus;* those in the *Epilachna* (Fig. 37, **24**) and *Ceropria* (Fig. 38, **24**), and the second epimero-subalar muscles in the *Rhaphidopalpa* (Fig. 39, **24**) arise on the posterior detached sclerites of the epimera, the first epimero-subalar muscles in the *Rhaphidopalpa* (Fig. 39, **23**) on the pleural ridges, the epimero-subalar muscles in the *Mimela* (Fig. 40, **24**) on the posterior margins of the epimera, and all these attach on the subalar sclerites. The episterno-subalar muscles are found in one pair on the *Epilachna* (Fig. 37, **25**) and *Rhaphidopalpa* (Fig. 39, **25**), arise on the lower portions of the episterna by wide bases and are attached to the subalar sclerites.

5) Sterno-Pleural Muscles

The *Cicindella* (Fig. 34, **21**) and *Chlaenius* (Fig. 35, **25**) have a pair of ordinary sterno-pleural muscles arising on the posterior sides of the bases of the profurcal arms and are attached to the anterior portions of the mesepisterna.

The *Borolinus* (Fig. 36, **24**), *Epilachna* (Fig. 37, **26**), *Ceropria* (Fig. 38, **25**) and *Rhaphidopalpa* (Fig. 39, **26**) have a pair of furco-entopleural muscles stretched between the furcal arms and the middle portions of the pleural ridges. The furco-entopleural muscles in the *Cicindella* and *Chlaenius* have been displaced by sclerotized bridges between the furca and the pleural ridges. The *Mimela* has neither sterno-pleural muscle nor sclerotized bridge.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors are found in a pair on the *Cicindella* (Fig.

34, **22**), but lack in the six others. Each muscle arises on the median of the anterior portion of the tergum by a wide base, and is attached to the small trochantin.

(*b*) *Sternal Promotors of the Coxae*

The *Cicindella* (Fig. 34, **23**), *Chlaenius* (Fig. 35, **26**), *Borolinus* (Fig. 36, **25**), *Ceropria* (Fig. 38, **26**), *Rhaphidopalpa* (Fig. 39, **27**) and *Mimela* (Fig. 40, **25**) have a sternal promotor arising on the furcal arm and attached on the anterior basal rim of the coxa on each side, but the *Epilachna* lacks it.

(*c*) *Tergal Remotors of the Coxae*

The seven species have a very thick tergal remotor on each side. The tergal remotor in the *Cicindella* (Fig. 34, **24**), *Chlaenius* (Fig. 35, **27**), and *Borolinus* (Fig. 36, **26**) arises on the anterior plate-like invagination of the tergum, in the *Epilachna* (Fig. 37, **27**) on the antero-median portion of the tergum by a wide base, in the *Ceropria* (Fig. 38, **27**), *Rhaphidopalpa* (Fig. 39, **28**) and *Mimela* (Fig. 40, **26**) on the antero-lateral portion of the tergum, and all these each take the insertion into the posterior basal rim of the coxa by a slender tendon.

(*d*) *Coxo-Subalar Muscles*

The coxo-subalar muscles are one-paired in the *Cicindella* (Fig. 34, **25**) and *Chlaenius* (Fig. 35, **28**). These are very slender muscles stretched between the postero-lateral basal rims of the coxae and the subalar sclerites. The five other species lack the coxo-subalar muscles.

(*e*) *Sternal Remotors of the Coxae*

The sternal remotors in the *Cicindella* (Fig. 34, **26**), *Chlaenius* (Fig. 35, **29**), *Borolinus* (Fig. 36, **27**), *Ceropria* (Fig. 38, **28**), *Rhaphidopalpa* (Fig. 30, **29**) and *Mimela* (Fig. 40, **27**) are one-paired, streching between the furcal arms and the posterior basal rims of the coxae; those in the *Epilachna* (Fig. 37, **28**, **29**) are two-paired, the first pair are similar to the sternal remotors in the former six species, the second are very slender muscles arising on the furcal arms and attached on the postero-lateral basal rims of the coxae.

(f) Tergal Abductors of the Coxae

The tergal abductors are found in one pair on the *Chlaenius* (Fig. 35, **30**) and *Mimela* (Fig. 40, **28**); these arise on the antero-lateral portions of the tergum and attach on the antero-lateral basal rim of the coxae lateral to the anterior coxo-trochantinal joints by tendons. The five other species lack the tergal abductors.

(g) Pleural Abductors of the Coxae, and Coxo-Basalar Muscles

The coxa in the seven species (Fig. 34, **27**; Fig. 35, **31**; Fig, 36, **28**; Fig. 37, **30**; Fig. 38, **29**; Fig. 39, **30**; Fig. 40, **29**) has a strong fan-shaped pleural abductor arising on the dorsal or middle portion of the episternum by a wide base and inserted into the antero-lateral basal rim of the coxa by a tendon.

The *Epilachna* (Fig. 37, **31**), *Ceropria* (Ffg. 38, **30**) and *Rhaphidopalpa* (Fig. 39, **31**) are provided with a pair of slender coxo-basalar muscles attached dorsally on the basalar apodemes and ventrally on the antero-lateral basal rims of the coxae.

7) Trochanteral Muscles Arising on the Thorax

(a) Tergal Depressors of the Trochanters

The trochanter in the *Cicindella* (Fig. 34, **28**) and *Chlaenius* (Fig. 35, **32**) has a thick tergal depressor arising on the anterior portion of the dorso-lateral region of the tergum and attached on the common depressor apodeme at the ventral base of the trochanter. The five other species lack the tergal depressors.

(b) Pleural Depressors of the Trochanters

The pleural depressors are divisible into two kinds: Episternal depressors arising on the dorsal or middle portions of the episterna, epimeral depressors arising on the dorsal portions of the epimera, and both are attached on the depressor apodemes of the trochanters.

The *Cicindella* (Fig. 34, **29**), *Borolinus* (Fig. 36, **29**), *Epilachna* (Fig. 37, **32**), *Ceropria* (Fig. 38, **31**) have an episternal pleural depressor, the *Chlaenius* (Fig. 35, **33, 34**) has two episternal pleural depressors, and the *Rhaphidopalpa* (Fig. 39, **32**) and *Mimela* (Fig. 40, **30**) have an epimeral pleural depressor, on each side.

(*c*) *Sternal Depressors of the Trochanters*

The *Cicindella* (Fig. 34, **30**), *Chlaenius* (Fig. 35, **35**), *Borolinus* (Fig. 36, **30**), *Epilachna* (Fig. 37, **33**), *Ceropria* (Fig. 38, **32**) and *Rhaphidopalpa* (Fig. 39, **33**) have a sternal depressor stretched between the furcal arm and the common depressor apodeme of the trochanter on each side, but the *Mimela* lacks it.

8) **Muscles of the Spiracles**

The seven species have an occlusor on each first thoracic spiracle. The occlusor in the *Cicindella* (Fig. 34, **31**) arises on the ventral end of the spiracle and is attached to the middle or somewhat dorsal portion of the anterior side of the spiracle, at that in the Lepidoptera. That in the others (Fig. 35, **36**; Fig. 36, **31**; Fig. 37, **34**; Fig. 38, **33**; Fig. 39, **34**; Fig. 40, **31**) arises on the ventral end of the subspiraculare and is inserted into the ventral side of the spiracle.

c. Metathoracic Musculature

1) **Dorsal Muscles**

The seven species (Fig. 34, **32, 33**; Fig. 35, **37, 38**; Fig. 36, **32, 32a**; Fig. 37. **35, 36**; Fig. 38, **34, 35**; Fig. 39, **35, 36**; Fig. 40, **32, 33**) have two dorsal muscles on each side, a median and a lateral oblique dorsal muscle. The median dorsal muscle is very thick, stretched between the second and third phragmata. The lateral oblique dorsal muscle is thick, it arises on the middle or somewhat anterior portion of the dorso-lateral region of the tergum at the antero-lateral side of the scutellum, and attaches on the lateral portion of the intersegmental ridge between the metatergum and first abdominal tergum.

2) **Ventral Muscles**

The *Cicindella* (Fig. 34, **34, 35**) and *Chlaenius* (Fig. 35, **39, 40**) have two ventral muscles on each side, a longitudinal and a spinofucal ventral muscle, these are similar to the mesothoracic ventral muscles in the *Chlaenius* (Fig. 35, **21, 22**). The *Borolinus* (Fig. 36, **33**), *Epilachna* (Fig. 37, **37**), *Ceropria* (Fig. 38, **36**), *Rhaphidopalpa* (Fig.

39, **37**) and *Mimela* (Fig. 40, **34**) have a longitudinal ventral muscle similar to that in the *Cicindella* on each side.

3) **Tergo-Sternal Muscles**

The seven species have a pair of thick anterior tergo-sternal muscles arising on the antero-lateral portions of the tergum and attached to both sides of the ventral median ridge (Fig. 34, **36**; Fig. 35, **41**; Fig. 36, **34**; Fig. 37, **38**; Fig. 38, **37**; Fig. 39. **38**; Fig. 40, **35**). The *Cicindella* (Fig. 34, **37**), *Chlaenius* (Fig. 35, **42**), *Borolinus* (Fig. 36, **35**) and *Rhaphidopalpa* (Fig. 39, **39**) have a pair of posterior tergo-sternal muscles similar to those in the mesothorax of the *Borolinus*, ect.. The *Epilachna* (Fig. 37, **39, 40**), *Ceropria* (Fig. 38, **38, 39**) and *Mimela* (Fig. 40, **36, 37**) have two pairs of posterior tergo-sternal muscles, an inner pair arising on the lateral portions (*Epilachna*) or median portions (*Ceropria, Mimela*) of the third phrag-mata, an outer pair arising on the lateral portions of the antero-lateral corners of the first abdominal tergum, and both are attached to the metafurcal arms.

4) **Tergo-Pleural Muscles**

The *Cicindella* has a pair of ordinary tergo-pleural muscles (Fig. 34, **38**) arising on the prealar sclerites and attached to the pleural wing processes; the *Chlaenius* (Fig. 33, **43, 44**), *Borolinus* (Fig. 36, **36, 37**), *Epilachna* (Fig. 37, **41, 42**), *Ceropria* (Fig. 38, **40, 41**), *Rhaphidopalpa* (Fig. 39, **40, 41**) and *Mimela* (Fig. 40, 38, **38, 39**) have two pairs of ordinary tergo-pleural muscles, one arising on the lateral marginal portions of the anterior region of the tergum and attached on the basalar sclerites, the other resembling the ordinary tergo-pleural muscles in the *Cicindella.*

The pleuro-axillary muscles are divisible into two kinds by their arising positions, episterno-axillary muscles arising on the upper regions of the episterna and attached on the third axillaries, epimero-axillary muscles arising on the upper regions of the epimera and inserted into the third axillaries. The *Chlaenius* (Fig. 35, **45**) *Borolinus* (Fig. 36, **38**), *Ceropria* (Fig. 38, **42**) and *Mimela* (Fig. 40, **40**) have an episterno-axillary muscle, the *Cicindella* (Fig. 34, **38, 40**) and *Epilachna*

(Fig. 37, 43, 44) have two fan-shaped episterno-axillary muscles, and the *Rhaphidopalpa* has three episterno-axillary muscles (Fig. 39, 42, 43, 44), on each side. The *Cicindella* (Fig. 34, 41), *Chlaenius* (Fig. 35, 46), *Borolinus* (Fig. 36, 39), *Epilachna* (Fig. 37, 45), *Ceropria* (Fig. 38, 43), *Rhaphidopalpa* (Fig. 39, 45) and *Mimela* (Fig. 40, 41) have a fan-shaped epimero-axillary muscle on each side.

The pleuro-subalar muscles are epimero-subalar muscles arising on the subalar sclerites and attached on the epimera, the dorsal epimeral detached sclerites or the anterior sides of the posterior lateral elongations of the tergum.

The *Cicindella* (Fig. 34, 42), *Chlaenius* (Fig. 35, 47), *Borolinus* (Fig. 36, 40), *Epilachna* (Fig. 37, 46), *Rhaphidopalpa* (Fig. 39, 46) and *Mimela* (Fig. 40, 42) have a pair of pleuro-subalar muscles, but the *Ceropria* lacks the pleuro-subalar muscles.

5) Sterno-Pleural Muscles

The seven species (Fig. 34, 43, 44; Fig. 35, 48, 49; Fig. 36, 41, 42; Fig. 37, 47, 48; Fig. 38, 44, 45; Fig. 39, 47, 48; Fig. 40, 43, 44) have a very thick sterno-basalar muscle arising on the ventro-lateral region of the sternum and inserted into the basalare, a fan-shaped furco-entopleural muscle arising on the furcal arm and attached on the ventral portion of the pleural ridge by a slender tendon, on each side.

6) Pleural Muscles

A pair of very thinly layered muscles arising on the lateral margins of the ventral plate and inserted into the episternum is found on the *Borolinus* (Fig. 36, 43), *Epilachna* (Fig. 37, 49), *Rhaphidopalpa* (Fig. 39, 49) and *Mimela* (Fig. 40, 45). These muscles may be homologous to the pleural muscles in the Dermaptera.

7) Coxal Muscles and Coxal Wing Muscles

(a) Tergal Promotors of the Coxae

The *Borolinus* (Fig. 36,44), *Epilachna* (Fig. 37, 50), *Ceropria* (Fig. 38, 46) and *Rhaphidopalpa* (Fig. 39, 50) are provided with a pair of tergal promotors arising on the antero-lateral portions of the tergum and inserted into the slender apodemes (*Borolinus*) or discs (*Epilachna*,

Ceropria and *Rhaphidopalpa*) of the anterior inner basal rims of the coxae, but *Cicindella*, *Chlaenius* and *Mimela* lack the tergal promotors.

(*b*) *Sternal Promotors of the coxae*

The sternal promotors are one-paired, arise on the furcal arms and attach on the antero-median basal rims of the coxae. (Fig. 34, **45**; Fig. 35, **50**; Fig, 36, **45**; Fig. 37, **51**; Fig. 38, **47**; Fig. 39, **51**; Fig. 40, **46**).

(*c*) *Tergal Remotors of the Coxae*

The *Cicindella* has two tergal remotors on each side, an inner bundle (Fig. 34, **46**) arising on the dorso-lateral portion of the tergum and inserted into the posterior wall of the coxa by a wide base, an outer bundle (Fig. 34, **47**) on the lateral portion of the tergum between the anterior and posterior notal wing processes and into the posterior basal margin of the coxa by a tendon. The *Chlaenius*, *Borolinus*, *Epilachna*, *Ceropria*, *Rhaphidopalpa* and *Mimela* have a tergal remotor on each side, the tergal remotor in the first species (Fig. 35, **51**) takes its origin on the postero-lateral portion of the tergum, in the second (Fig. 36, **46**) on the anterior portion of the dorso-lateral region of the tergum, in the third (Fig. 37, **52**), fourth (Fig. 38, **48**), fifth (Fig. 39, **52**) and sixth (Fig. 40, **47**) on the middle portion of the lateral region of the tergum, all these each take the insertion into the posterior basal rim of the coxa.

(*d*) *Coxo-Subalar Muscles*

A coxo-subalar muscle is found on each side of the seven species. That in the *Cicindella* (Fig. 34, **48**) arises on the postero-lateral wall of the coxa, in the *Epilachna* (Fig. 37, **53**) on the postero-lateral basal margin of the coxa, in the *Chlaenius* (Fig. 30, **52**), *Borolinus* (Fig. 36, **47**), *Rhaphidopalpa* (Fig. 39, **53**) and *Mimela* (Fig. 40, **48**) on the antero-lateral basal wall of the coxa, all these each take the dorsal attachment on the subalar disc.

(*e*) *Sternal Remotors of the Coxae*

The *Cicindella* (Fig. 34, **49**), *Borolinus* (Fig. 36, **48**), *Epilachna* (Fig. 37, **54**), *Ceropria* (Fig. 38, **50**), *Rhaphidopalpa* (Fig. 39, **54**) and

Mimela (Fig. 40, **49**) have an ordinary sternal remotor similar to their mesothoracic sternal remotor on each side, but the *Chlaenius* lacks it.

(*f*) *Sternal Adductors of the Coxae*

A pair of fan-shaped sternal adductors arising on the furcal arms and attached on the strong apodemes of the inner bases of the coxae are found on the *Chlaenius* (Fig. 35, **53**), but lacking in the six others.

(*g*) *Tergal Abductors of the Coxae*

The *Chlaenius* (Fig. 35, **54**), *Borolinus* (Fig. 36, **49**), *Ceropria* (Fig. 38, **51**) and *Mimela* (Fig. 40, **50**) have a tergal abductor arising on the antero-lateral portion of the tergum and inserted into the antero-lateral wall of the coxa on each side, but the *Cicindella*, *Epilachna* and *Rhaphidopalpa* lack it.

(*h*) *Pleural Abductors of the Coxae aud Coxo-Basalar Muscles*

The *Chlaenius* has a pair of coxo-basalar muscles (Fig. 35, **55**) arising on the antero-lateral basal rims of the coxae and attached on the basalar sclerites, but lacks the pleural abductors; while the *Borolinus* (Fig. 36, **50**), *Epilachna* (Fig. 37, **55**) and *Mimela* (Fig. 40, **51**) have a pair of pleural abductors arising on the episterna along the pleural ridges by wide bases and inserted into the antero-lateral basal rims of the coxae by slender tendons, but lack the coxo-basalar muscle; the *Ceropria* (Fig. 38, **52, 53**) and *Rhaphidopalapa* (Fig. 39, **55, 56**) have both the pleural abductor and the coxo-basalar muscle, which are similar to those in the above species respectively.

8) **Trochanteral Muscles Arising on the Thorax**

The seven species have only a very thick sternal depressor stretched between the furcal arm and the depressor apodeme of the trochanter on each side (Fig. 34, **50**; Fig. 35. **56**; Fig. 36, **51**; Fig. 37, **56**; Fig. 38, **54**; Fig. 39, **57**; Fig. 40, **52**).

9) **Muscles of the Spiracles**

The second thoracic spiracle in the seven species has an occlusor on the ventral side of the spiracle. The occlusor in the *Cicindella* (Fig. 34, **51**), *Chlaenius* (Fig. 35, **57**), *Borolinus* (Fig. 36, **52**), *Epilachna* (Fig. 37, **57**), *Ceropria* (Fig. 38, **55**) and *Rhaphidopalpa* (Fig. 39, **58**)

TABLE XVI

Coleoptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and

a) Prothoracic

	Cicindelidae. *Cicindela kaleea* (Fig. 34)	Dytiscidae. *Dytiscus marginalis* (BAUER, 1910)	Carabidae. *Chlaenius naeviger* (Fig. 35)
Dorsal Muscles.			
Median dorsals.	2 (1) (2)	2(lh) (dpr)	2 (1) (2)
Lateral dorsals.	1 (3)	1(rtp)	1 (3)
Anterior dorsals.	2 (4) (5)	1(rts)	1 (4)
Ventral Muscles.			
Internal longitudinal ventrals.	2 (6) (7)	1(rti)	2 (5) (6)
External ventrals.	—	—	—
Tergo-Sternal Muscles.			
Anterior intersegmental tergo-sternals.	1 (8)	1(lv)	1 (7)
Anterior internal tergo-sternals.	2 (9) (10)	2(dv) (do)	2 (8) (9)
Posterior tergo-sternals.	1(11)	1(lpr)	1(10)
Tergo-Pleural Muscles.			
Ordinary tergo-pleurals.	—	—	1(11)
Anterior tergo-pleurals.	—	—	—
Coxal Muscles.			
Tergal promotors.	2(12) (13)	3 (ecIa) (ecIb) (ecIc)	2 (12) (13)
Pleural promotors.	—	—	1(14)
Tergal remotors.	2(14) (15)	1(fcIa)	3 (15) (16) (17)
Pleural remotors.	—	—	—
Ordinary sternal remotors.	1(16)	1(fcIb)	1(18)
Pleural abductors.	—	—	—
Trochanteral Muscles Arising on the Thorax.			
Tergal depressors.	1(17)	—	—
Pleural depressors.	—	1(etrI)	1(19)

letters show the signs used in the figures; "—" shows the absence of muscles)

Musculature

Staphylinidae. *Borolinus minutus* (Fig. 36)	Coccinellidae. *Epilachna vigintiocto-punctata* (Fig. 37)	Hydrophilidae *Hydrophilus piceus* (BERLESE, 1909)	Tenebrioni-dae. *Ceropria induta* (Fig. 38)	Chrysomeli-dae. *Rhaphidopalpa femoralis* (Fig. 39)	Scarabaeidae. *Mimela testaceoviri-dis* (Fig. 40)
2 (1)	2 (1)	1(140)	3 (1)	2 (1)	1 (1)
(2)	(2)		(2)	(2)	
			(3)		
1 (3)	1 (3)	1(110)	1 (4)	1 (3)	2 (2)
					(3)
1 (4)	1 (4)	—	—	1 (4)	1 (4)
1 (5)	2 (5)	1(137)	1 (5)	2 (5)	1 (5)
	(6)			(6)	
1 (6)	2 (7)	—	1 (6)	1 (7)	1 (6)
	(8)				
2 (7)	2 (9)	1(147)	1 (7)	1 (8)	2 (7)
(8)	(10)				(8)
1 (9)	2(11)	3(CXL)	3 (8)	2 (9)	2 (9)
	(12)	(143)	(9)	(10)	(10)
		(144)	(10)		
1 (10)	1(13)		1(11)	1(11)	1(11)
1(11)	1(14)	—	1(12)	1(12)	1(12)
—	—	1(136)	—	—	—
1(12)	1(15)		1(13)	1(13)	—
1(13)	—		—	—	—
2(14)	1(16)		2(14)	1(14)	2(13)
(15)			(15)		(14)
—	—		—	—	1(15)
-	1(17)		—	1(15)	—
—	-		1(16)	1(16)	1(16)
—	—		—	—	—
1(16)	1(18)		3(17)	1(17)	1(17)
			(18)		
			(19)		

b) Mesothoracic

	Cicindelidae. *Cicindela kaleea* (Fig. 34)	Dytiscidae. *Dytiscus marginalis* (BAUER, 1910)	Carabidae. *Chlaenius naeviger* (Fig. 35)
Dorsal Muscles.			
Median dorsals.	1(18)	2(msi) (mss)	1(20)
Lateral dorsals.	—	—	—
Ventral Muscles.			
Longitudinal ventrals.	1(19)	1(rtrp)	1(21)
Mesospino-mesofurcal ventrals.	—	—	1(22)
Tergo-Sternal Muscles.			
Anterior tergo-sternals.	—	—	—
Posterior tergo-sternals.	—	1(lm)	—
Tergo-Pleural Muscles.			
Ordinary tergo-pleurals.	—	1(le)	1(23)
Pleuro-axillary muscles.	1(20)	1(de)	1(24)
Pleuro-subalar muscles.			
Epimero-subalar muscles.	—	—	—
Episterno-subalar muscles.	—	—	—
Sterno-Pleural Muscles.			
Ordinary sterno-pleurals.	1(21)	—	1(25)
Furco-entopleural muscles.	—	1(fulII)	—
Coxal Muscles and Coxal Wing Muscles.			
Tergal promotors of the coxa.	1(22)	—	—
Ordinary sternal promotors of the coxa.	1(23)	1(fcIIc)	1(26)
Tergal remotors of the coxa.	1(24)	2(ecIIa) (ecIIc)	1(27)
Coxo-subalar muscles.	1(25)	1(ecIId)	1(28)
Ordinary sternal remotors of the coxa.	1(26)	2(ecIIb) (ecIIe)	1(29)
Tergal abductors of the coxa.	—	1(fcIIa)	1(30)
Pleural abductors of the coxa.	1(27)	1(fcIIb)	1(31)
Coxo-basalar muscles.	—	—	—
Trochanteral Muscles Arising on the Thorax.			
Tergal depressors.	1(28)	3(etrIIb) (etrIIc) (etrIId)	1(32)
Pleural depressors.			
Episternal depressors.	1(29)	1(etrIIe)	2(33) (34)
Epimeral depressors.	—	—	—
Sternal depressors.	1(30)	1(etrIIa)	1(35)
Muscles of the Spiracle.	1(31)		1(36)

Musculature

Staphylinidae. *Borolinus minutus* (Fig. 36)	Coccinellidae. *Epilachna vigintiocto-punctata* (Fig. 37)	Hydrophilidae *Hydrophilus piceus* (BERLESE, 1909)	Tenebrionidae. *Ceropria induta* (Fig. 38)	Chrysomelidae. *Rhaphidopalpa femoralis* (Fig. 39)	Scarabaeidae. *Mimela testaceoviridis* (Fig. 40)
1(17)	1(19)	1(70)	1(20)	1(18)	1(18)
1(18)	1(20)	1(71)	1(21)	1(19)	—
1(19)	1(21)	1(105+106)	1(22)	1(20)	1(19)
—	—	—	—	—	—
1(20)	—	—	—	—	—
1(21)	—	—	—	—	1(20)
1(22)	1(22)	1 LXXXI)	1(23)	1(21)	2(21) (22)
1(23)	1(23)	1(LXXXI)	—	1(22)	1(23)
—	1(24)	1(CIa)	1(24)	2(23) (24)	1(24)
—	1(25)	—	—	1(25)	—
—	—	—	—	—	—
1(24)	1(26)	—	1(25)	1(26)	—
—	—	—	—	—	—
1(25)	—	—	1(26)	1(27)	1(25)
1(26)	1(27)	1(LXXXIII)	1(27)	1(28)	1(26)
—	—	—	—	—	—
1(27)	3(28) (29)	1(94)	1(28)	1(29)	1(27)
—	—	—	—	—	1(28)
1(28)	1(30)	2(80) (80a)	1(29)	1(30)	1(29)
—	1(31)	1(79)	1(30)	1(31)	—
—	—	1(76)	—	—	—
1(29)	1(32)	—	1(31)	—	—
—	—	3(96) (96a) (LXXXV)	—	1(32)	1(30)
1(30)	1(33)		1(22)	1(33)	—
1(31)	1(34)		1(33)	1(34)	1(31)

c) Metathoracic

	Cicindelidae. *Cicindela kaleea* (Fig. 34)	Dytiscidae. *Dytiscus marginalis* (BAUER, 1910)	Carabidae. *Chlaenius naeviger* (Fig. 35)
Dorsal Muscles.			
Median dorsals.	1(32)	1(mdIII)	1(37)
Lateral dorsals.	1(33)	1(ltpIII)	1(38)
Ventral Muscles.			
Longitudinal ventrals.	1(34)	1(rtrm)	1(39)
Metaspino-metafurcal ventrals.	1(35)	—	1(40)
Tergo-Sternal Muscles.			
Anterior tergo-sternals.	1(36)	1 ltaIII)	1(41)
Posterior tergo-sternals.	1(37)	1(fudIII)	1(42)
Tergo-Pleural Musclee.			
Ordinary tergo-pleurals.	1(38)	2(re) (ra)	2(43) (44)
Pleuro-axillary muscles.	3(39) (40) (41)	1(fa)	2(45) (46)
Pleuro-subalar muscles.	1(42)	—	1(47)
Sterno-Pleural Muscles.			
Sterno-basalar muscles.	7(43)	1(eaa)	1(48)
Furco-entopleural muscles.	1(44)	1(fulIII)	1(49)
Pleural Muscles.	—	1(ex)	—
Coxal Muscles and Coxal Wing Muscles.			
Tergal promotors of the coxa.	—	—	—
Ordinary sternal promotors of the coxa.	1(45)	—	1(50)
Tergal remotors of the coxa.	2(46) (47)	3(ltmIII) (cdIII) (clIII)	1(51)
Coxo-subalar muscles.	1(48)	1(eap)	1(52)
Ordinary sternal remotors of the coxa.	1(49)	1(fucIII)	—
Sternal adductors of the coxa.	—	—	1(53)
Tergal abductors of the coxa.	—	—	1(54)
Pleural abductors of the coxa.	—	—	—
Coxo-basalar muscles.	—	—	1(55)
Trochanteral Muscles Arising on the Thorax.			
Sternal depressors.	1(50)	3(etrIIIa) (etrIIIp) (etrIIIm)	1(56)
Muscles of the Spiracle.	1(51)		1(57)

Musculature

Staphylinidae. *Borolinus minutus* (Fig. 36)	Coccinellidae. *Epilachna vigintiocto-punctata* (Fig. 37)	Hydrophilidae *Hydrophilus piceus* (BERLESE, 1909)	Tenebrionidae. *Ceropria induta* (Fig. 38)	Chrysomelidae. *Rhaphidopalpa femoralis* (Fig. 39)	Scarabaeidae. *Mimela testaceoviridis* (Fig. 40)
1(32) 1(32a)	1(35) 1(36)	1(37) 1(38)	1(34) 1(35)	1(35) 1(36)	1(32) 1(33)
1(33) —	1(37) —	1(68) —	1(36) —	1(37) —	1(34) —
1(34) 1(35	1(38) 2(39) (40)	1(XXXVI) 2(XXXIII) (41)	1(37) 2(38) (39)	1(38) 1(39)	1(35) 2(36) (37)
2(36) (37) 2(38) (39) 1(40)	2(41) (42) 3(43) (44) (45) 1(46)	2(56) (LVI) 1 (59) —	2(40) (41) 2(42) (43) —	2(40) (41) 4(42) (43) (44) (45) 1(46)	2(38) (39) 2(40) (41) 1(42)
1(41) 1(42)	1(47) 1(48)	1(LXI) 1(65)	1(44) 1(45)	1(47) 1(48)	1(43) 1(44)
1(43)	1(49)	2(LXII)	—	1(49)	1(45)
1(44) 1(45) 1(46) 1(47) 1(48) — 1(49) 1(50) —	1(50) 1(51) 1(52) 1(53) 1(54) — — 1(55) —	— 2(60) (62) 1(43) 1(XLIX) — 1(42)? 1(51) 1(LXIV)	1(46) 1(47) 1(48) 1(49) 1(50) — 1(51) 1(52) 1(53)	1(50) 1(51) 1(52) 1(53) 1(54) — — 1(55) 1(56)	— 1(46) 1(47) 1(48) 1(49) — 1(50) 1(51) —
1(51)	1(56)	1(63)	1(54)	1(57)	1(52)
1(52)	1(57)		1(55)	1(58)	1(53)

d) Abdominal Musculature

	Cicindelidae. *Cicindela kaleea* (Fig. 34)	Carabidae. *Chlaenius naeviger* (Fig. 35)	Staphylinidae. *Borolinus minutus* (Fig. 36)	Coccinellidae. *Epilachna vigintiocto-punctata* (Fig. 37)	Tenebrionidae. *Ceropria induta* (Fig. 38)	Chrysomelidae. *Rhaphidopalpa femoralis* (Fig. 39)	Scarabaeidae. *Mimela testaceoviridis* (Fig. 40)
I Segment							
Dorsal Muscles.	2(52) (53)	1(58)	2(53) (54)	4(58) (59) (60) (61)	3(56) (57) (53)	2(59) (60)	2(54) (55)
Dorsal Transverse Muscles.	—	1(59)	—	—	—	—	—
Ventral Muscles.	—	2(60) (61)	1(55)	3(62) (63) (64)	1(59)	2(61) (92)	2(56) (57)
Tergo-Sternal Muscles.	—	3(62) (63) (64)	1(56)	2(65) (66)	3(60) (61) (62)	1(63)	2(58) (59)
Sterno-Pleural Muscles.	1(54)	1(65)	—	—	—	4(64) (65) (66)	—
Occlusor of the Spiracle.	1(55)	1(66)	1(57)	1(67)	1(63)	1(67)	1(60)
Dorsal Dilator of the Spiracle.	1(56)	—	—	—	1(64)	—	—
Ventral Dilator of ths Spiracle.	—	—	—	1(68)	1(65)	—	—
II Segment							
Dorsal Muscles.	3(57) (58) (59)	3(67) (68) (69)	2(58) (59)	5(69) (70) (71) (72) (73)	6(66) (67) (68) (69) (70) (71)	3(68) (69) (70)	1(61)
Dorsal Transverse Muscles.	1(60)	1(70)	—	1(74)	1(72)	1(71)	1(62)
Ventral Muscles.	1(61)	1(71)	2(60) (61)	—	1(73)	1(72)	2(63) (64)
Tergo-Sternal Muscles.	1(62)	8(72) (73) (74)	—	1(75)	4(74) (75) (76) (77)	1(73)	2(65) (66)
Sterno-Pleural Muscles.	—	1(75)	—	1(76)	1(78)	1(74)	—
Occlusor of the Spiracle.	1(63)	1(79)	1(62)	1(77)	1(79)	1(75)	1(67)
Dorsal Dilator of the Spiracle.	—	—	—	—	1(80)	—	—

III Segment							
Dorsal Muscles.	3 (64) (65) (66)	3 (77) (78) (79)	2 (63) (64)	5 (78) (79) (80) (81) (82)	6 (81) (82) (83) (84) (85) (86)	3 (76) (77) (78)	1 (68)
Dorsal Transverse Muscles.	1 (67)	1 (80)	1 (65)	1 (83)	1 (87)	1 (79)	1 (69)
Ventral Muscles.	—	—	1 (66)	—	—	2 (80) (81)	1 (70)
Tergo-Sternal Muscles.	1 (68)	3 (81) (82) (83)	—	3 (84) (85) (86)	5 (88) (89) (90) (91) (92)	1 (82)	2 (71) (72)
Sterno-Pleural Muscles.	—	1 (84)	—	1 (87)	1 (93)	2 (83) (84)	—
Occlusor of the Spiracle.	1 (69)	1 (85)	1 (67)	1 (88)	1 (94)	1 (85)	1 (73)
Dorsal Dilator of the Spiracle.	—	—	—	—	1 (95)	—	—
IV–VI Segments							
Dorsal Muscles.	3 (70) (71) (72)	3 (86) (87) (88)	2 (63) (64)	5 (89) (90) (91) (92) (93)	6 (81) (82) (83) (84) (85) (86)	3 (76) (77) (78)	1 (74)
Dorsal Transverse Muscles.	3 (73) (74) (75)	1 (89)	1 (65)	1 (94)	1 (87)	1 (79)	1 (75)
Ventral Muscles.		2 (90) (91)	1 (66)	2 (95) (96)	— in IV. 2 (66) (97) in V. 1 (98) in VI.	2 (80) (81)	1 (76)
Tergo-Sternal Muscles.	1 (76)	3 (92) (93) (94)	—	3 (97) (98) (99)	5 (88) (89) (90) (91) (92)	1 (82)	2 (77) (78)
Sterno-Pleural Muscles.	—	1 (95)	—	1 (100)	1 (93)	2 (83) (84)	—
Occlusor of the Spiracle.	1 (77)	1 (96)	1 (67)	1 (101)	1 (94)	1 (85)	1 (79)
Dorsal Dilator of the Spiracle.	—	—	—	—	1 (94)	—	—

arises on the ventral end of the subspiraculare, that in the *Mimela* (Fig. 40, **53**) on the postero-ventral corner of the mesepimeron.

The thoracic muscles are tabulated above, including those of some other species observed by other authors.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figures 34–40 and Table XVI.

16. HYMENOPTERA

Tenthredinidae. *Eutomostethus formosanus* ENSLIN (Fig. 41)
Ichneumonidae. *Philopsyche sauteri* CUSHMAN (Fig. 42)
Vespidae. *Vespa ducalis* SMITH (Fig. 43)

a. Prothoracic Musculature

1) Dorsal Muscles

The *Vespa ducalis* has three dorsal muscles on each side: A long slender oblique dorsal muscle (Fig. 43, **1**) arising on the dorsal median portion of the posterior end of the head, a short fan-shaped oblique dorsal muscle (Fig. 43, **2**) originating on the median portion of the protergum, a short fan-shaped oblique dorsal muscle (Fig. 43, **3**) arising on the anterior portion of the dorso-lateral region of the tergum. All these are attached to the antero-lateral margin of the mesotergum. The *Eutomostethus formosanus* and *Philopsyche sauteri* have no dorsal muscle.

2) Ventral Muscles

The *Eutomostethus* (Fig. 41, **1**; **2**) and *Vespa* (Fig. 43, **4**; **5**) have two ventral muscles on each side: An internal bundle stretched between the ventro-lateral portion of the posterior end of the head and the furcal arm, and an external or cervico-furcal bundle stretched between the ventro-lateral sclerite and the furcal arm. The *Philopsyche* (Fig. 42, **1**; **2**, **3**) has an internal and two external ventral mus-

cles similar to the ventral muscles of the two others in the attached positions, on each side.

3) **Ventral Transverse Muscles**

A pair of ventral transverse muscles arising on the furcal arms and attached on the spina at the anterior end of the mesosternum are found on the *Eutomostethus* (Fig. 41, **3**), but lacking in the *Philopsyche* and *Vespa*.

4) **Tergo-Sternal Muscles**

In the tergo-sternal muscles there are found two kinds, anterior intersegmental tergo-sternals and anterior internal tergo-sternals. The anterior intersegmental tergo-sternal muscles are two-paired in the *Eutomostethus* (Fig. 41, **4, 5**) and *Vespa* (Fig. 43, **6, 7**), three-paired in the *Philopsyche* (Fig. 42, **4, 5, 6**); in the *Eutomostethus* and *Vespa* the first pair (Fig. 41, **4**; Fig. 43, **6**) arise on the ventral portions of the lateral sclerites by wide bases, the second (Fig. 41, **5**; Fig. 43, **7**) on the furcal arms; in the *Philopsyche*, the first pair (Fig. 42, **4**) take the origins on the ventro-lateral cervical sclerites, the second (Fig. 42, **5**) on the ventral portions of the lateral sclerites, and the third (Fig. 42, **6**) on the furcal arms; all these pairs take their insertions into the dorso-lateral portions of the posterior end of the head.

The *Eutomostethus* has a pair of anterior internal tergo-sternal muscles (Fig. 41, **6**) arising on the dorso-lateral portions of the tergum and inserted into the anterior portions of the lateral plates by tendons. The *Philopsyche* (Fig. 42, **7, 8**) and *Vespa* (Fig. 43, **8, 9**) have two pairs of anterior internal tergo-sternal muscles, the first pair arising on the first phragmata, the second on the dorso-lateral portions of the tergum near the antero-lateral margins of the mesotergum, and both take the ventral attachments on the ventro-lateral cervical sclerites.

5) **Tergo-Pleural Muscles**

The tergo-pleural muscles divide into two kinds, anterior tergo-pleurals arising on the dorso-lateral portions of the posterior end of the head and attached on the dorsal portions of the pleura, and ordinary tergo-pleurals stretched between the tergum and the dorsal portions of the pleura. The anterior tergo-pleurals are found in one

pair on the *Eutomostethus* (Fig. 41, **7**) and *Vespa* (Fig. 43, **10**). The ordinary tergo-pleural muscles are two-paired in the *Eutomostethus* (Fig. 41, **8, 9**) and *Philopsyche* (Fig. 42, **9, 10**), and three-paired in the *Vespa* (Fig. 43, **11, 12, 13**).

6) Coxal Muscles

(*a*) *Sternal Promotors of the Coxae*

The *Eutomostethus* (Fig. 41, **10, 11**), *Philopsyche* (Fig. 42, **11, 12**) and *Vespa* (Fig. 43, **14, 15**) have an anterior cervical promotor arising on the ventro-lateral cervical sclerite (the last two species) or the anterior end of the ventro-lateral cervical sclerite (first species) of the opposite side and inserted into the anterior basal rim of the coxa, and an ordinary sternal promotor arising on the sternal median ridge and inserted into the anterior basal rim of the coxa, on each side.

(*b*) *Tergal Remotors of the Coxae*

On each side of the *Eutomostethus* (Fig. 41, **12**), *Philopsyche* (Fig. 42, **13**) and *Vespa* (Fig. 43, **16**) is found a tergal remotor arising on the latero-dorsal region of the tergum by a wide base, and inserted into the posterior basal rim of the coxa.

(*c*) *Pleural Remotors of the Coxae*

The *Vespa* has a pair of pleural remotors (Fig. 43, **17**) arising on the posterior sides of the pleural arms and attached on the posterior basal rims of the coxae by slender tendons, but the two others lack the pleural remotors.

(*d*) *Sternal Remotors of the Coxae*

The *Eutomostethus* has three sternal remotors on each side: A posterior spinal remotor (Fig. 41, **13**) arising on the spina of the anterior end of the median region of the mesosternum and inserted into the postero-lateral basal rim of the coxa; two ordinary sternal remotors, one (Fig. 41, **14**) originating on the furcal arm and inserted into the postero-lateral basal rim of the coxa, the other (Fig. 41, **15**) on the furcal arm and into the posterior basal rim of the coxa. The *Philopsyche* has two sternal remotors on each side, a posterior spinal remotor (Fig. 42, **14**) similar to that in the *Eutomostethus*, an

ordinary sternal remotor (Fig. 42, **15**) similar to the second ordinary sternal remotor in the *Eutomostethus* (Fig. 41, **15**). The *Vespa* (Fig. 43, **18**) has only an ordinary sternal remotor similar to that in the *Philopsyche*, on each side.

(*e*) *Pleural Abductors of the Coxae*

The pleural abductors are one-paired in the *Eutomostethus* (Fig. 41, **16**), two-paired in the *Philopsyche* (Fig. 42, **16, 17**) and *Vespa* (Fig. 43, **19, 20**). These are fan-shaped, arise on the episterna along the pleural ridges and attach on the antero-lateral basal rims of the coxae.

7) Trochanteral Muscles Arising on the Thorax

On each side of the *Eutomostethus* (Fig. 41, **17**), *Philopsyche* (Fig. 42, **18**) and *Vespa* (Fig. 43, **21**) is a pleural depressor arising on the ventral portion of the pleural ridge and inserted into the common depressor apodeme of the ventral base of the trochanter.

b. Mesothoracic Musculature

1) Dorsal Muscles

In the dorsal muscles are found median dorsal muscles and lateral dorsal muscles. The median dorsal muscles are divisible into internal dorsals and external dorsals. The internal median dorsals in the *Eutomostethus* (Fig. 41, **18**), *Philopsyche* (Fig. 42, **19**) and *Vespa* (Fig. 43, **22**) are one-paired, very thick, arising on the anterior median portion of the tergum and attached on the third phragmata. The external median dorsals in the *Eutomostethus* are two-paired and very slender, the first pair (Fig. 41, **19**) arise on the posterior median region of the scutum at the posterior ends of the notaulices, the second pair (Fig. 41, **20**) are shorter than the first, arising on the anterior end of the scutellum. Both are inserted into one-paired apodemes on the median membrane dividing the postnotum into two halves. The external median dorsals in the *Philopsyche* (Fig. 42, **20, 21**) are similar to those in the *Eutomostethus* (Fig. 41, **19, 20**), except that the former are unpaired. The external median dorsals in the *Vespa* (Fig. 43, **23**)

are one-paired, very similar to the second external median dorsals in the *Eutomostethus* (Fig. 41, **20**).

The lateral dorsal muscles are found in a pair on the *Eutomostethus* (Fig. 41, **21**). They are strong, arise on the posterior median portion of the scutum and are attached to the lateral portions of the second phragmata.

2) Ventral Muscles

The *Eutomostethus* (Fig. 41, **22, 23**), *Philopsyche* (Fig. 42, **22, 23**) and *Vespa* (Fig. 43, **24, 25**) have two pairs of longitudinal ventral muscles arising on the profurcal arms, inserted into the mesofurcal arms, and exceptionally into the median ridge in the second ventral muscles of the *Vespa* (Fig. 43, **25**).

3) Tergo-Sternal Muscles

On each side of the *Eutomostethus* (Fig. 41, **24**), *Philopsyche* (Fig. 42, **24**) and *Vespa* (Fig. 43, **26**) is found a very thick anterior vertical tergo-sternal muscle arising on the middle of the dorso-lateral region of the tergum and inserted into the sternal region at the outside of the ventral median ridge. The *Eutomostethus* has two pairs of slender posterior tergo-sternal muscles (Fig. 41, **25, 26**), the *Philopsyche* (Fig. 42, **25**) and *Vespa* (Fig. 43, **27**) have one pair of slender posterior tergo-sternal muscles; all these arise on the lateral portions of the second phragmata and attach on the mesofurcal arms.

4) Tergo-Pleural Muscles

Three kinds of tergo-pleural muscles are found, ordinary tergo-pleural muscles, pleuro-axillary muscles and pleuro-subalar muscles. The *Eutomostethus* has three ordinary tergo-pleural muscles on each side, the first (Fig. 41, **27**) arising on the anterior notal wing process and inserted into the basalare, the second (Fig. 41, **28**) on the antero-lateral corner of the tergum and into the pleural wing process, the third (Fig. 41, **29**) on the lateral portion of the tergum between the anterior and posterior notal wing processes and into the pleural ridge. The *Philopsyche* (Fig. 42, **26**) and *Vespa* (Fig. 43, **28**) have a tergo-pleural muscle arising on the lateral portion of the tergum be-

tween the anterior and posterior notal wing processes and inserted into the episternum by a wide base, on each side.

The *Eutomostethus* has two pleuro-axillary muscles on each side, one (Fig. 41, **30**) arising on the position somewhat dorsal to the middle portion of the pleural ridge by a wide base and inserted into the anterior side of the third axillary by a tendon, the other (Fig. 41, **31**) on the pleural ridge near the pleural wing process and into the third axillary. The *Philopsyche* has a pleuro-axillary muscle (Fig. 42, **29**) originating on the dorsal portion of the epimeron and inserted into the third axillary, and two pleuro-axillary muscles (Fig. 42, **27, 28**) on the episternal region by wide bases and into the third axillary by tendons, on each side. The *Vespa* has two pairs of pleuro-axillary muscles (Fig. 43, **29, 30**) similar to the pleuro-axillary muscles in the *Philopsyche* (Fig. 42, **27, 28**).

The pleuro-subalar muscles are found in a pair on the *Vespa* (Fig. 43, **31**). These arise on the lower portions of the episternal regions by wide bases and attach on the subalar sclerite by small tendons.

5) Sterno-Pleural Muscles

Two kinds of sterno-pleural muscles are found, sterno-basalar muscles and furco-entopleural muscles. The *Eutomostethus* (Fig. 41, **32**) has a very thick anterior sterno-basalar muscle arising on the ventro-lateral portion of the sterno-pleural region at the outside of the anterior tergo-sternal muscle (Fig. 41, **24**) and attached on the basalar disc. The *Philopsyche* has two anterior sterno-pleural muscles on each side, the first (Fig. 42, **30**) arising on the lateral intersegmental ridge at the anterior end of the pleuron and inserted into the posterior portion of the basalar disc, the second (Fig. 42, **31**) on the sterno-pleural region at the outside of the anterior tergo-sternal muscle (Fig. 42, **24**) and into the basalar disc. The *Vespa* has a pair of slender sterno-pleural muscles (Fig. 43, **32**) similar to the first sterno-pleural muscles in the *Philopsyche* (Fig. 42, **30**), but arising on the small internal processes of the antero-lateral corners of the ventral region and attached on the slender basalar apodemes.

The furco-entopleural muscles are found in two pairs on the *Eutomostethus* (Fig. 41, **33**, **34**) and *Vespa* (Fig. 43, **33**, **34**), dorsal and ventral; the dorsal pair in the first species are very thick, arising on the middle portions of the pleural ridges, the dorsal pair in the second species on the dorsal portions of the pleural ridges; the ventral pair in both species arise on the pleural wing processes by tendons; all these attach on the furcal arms. The furco-entopleural muscles in the *Philopsyche* (Fig. 42, **32**) are one-paired, arising on the middle portions of the pleural ridges by wide bases and attached on the furcal arms.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Sternal Promotors of the Coxae*

On each side of the *Eutomostethus* (Fig. 41, **35**), *Philopsyche* (Fig. 42, **33**) and *Vespa* (Fig. 43, **35**) is found a very thick sternal promotor of the coxa arising on the ventral median ridge or the base of the furca by a wide base and inserted into the anterior basal rim of the coxa.

(*b*) *Coxo-Subalar Muscles*

The *Eutomostethus* (Fig. 41, **36**) and *Philopsyche* (Fig. 42, **34**) have a pair of coxo-subalar muscles arising on the postero-lateral rims of the coxae by tendons and inserted into the subalar discs. The *Vespa* lacks the coxo-subalar muscles.

(*c*) *Sternal Remotors of the Coxae*

The sternal remotors in the *Eutomostethus* (Fig. 41, **37**), *Philopsyche* (Fig. 42, **35**) and *Vespa* (Fig. 43, **36**) are one-paired, stretching between the furcal bases and the posterior bases of the coxae.

(*d*) *Pleural Abductors of the Coxae*

On each side of *Eutomostethus* (Fig. 41, **38**) and *Vespa* (Fig. 43, **36**) there is a strong pleural abductor arising on the episternum near the pleural ridge by a very broad base and attached on the antero-lateral basal rim of the coxa by a tendon.

7) Trochanteral Muscles Arising on the Thorax

A pair of sternal depressors arising on the furcal arms and inserted into the depressor apodemes of the ventral bases of the tro-

chanters are found on the *Eutomostethus* (Fig. 41, **30**), *Philopsyche* (Fig. 42, **37**) and *Vespa* (Fig. 43, **37**).

8) Muscles of the Spiracles

Each first thoracic spiracle has an occlusor. The occlusor in the *Eutomostethus* (Fig. 41, **40**) arises on the posterior portion of the protergum, in the *Philopsyche* (Fig. 42, **38**) and *Vespa* (Fig. 43, **38**) on the intersegmental ridge between the protergum and mesopleuron. The occlusor in all these species takes its insertion into the ventral side of the spiracle.

c. Metathoracic Musculature

1) Dorsal Muscles

The *Eutomostethus* has three dorsal muscles on each side: A median internal dorsal muscle (Fig. 41, **41**) stretched between the second and third phragmata near the dorsal median line, an oblique median dorsal muscle (Fig. 41, **42**) arising on the antero-median portion of the tergum and attached on the third phragma externally to the median internal muscle, a lateral dorsal muscle (Fig. 41, **43**) stretched between the lateral portions of the second and third phragmata.

The *Philopsyche* (Fig. 42, **39**) and *Vespa* (Fig. 43, **39**) have a thick median dorsal muscle similar to the median internal dorsal muscle of the *Eutomostethus* on each side, but lack the lateral dorsal muscles.

2) Ventral Muscles

On each side of the *Eutomostethus* (Fig. 41, **44**), *Philopsyche* (Fig. 42, **40**) and *Vespa* (Fig. 43, **40**) there is a very thick longitudinal ventral muscle stretched between the meso- and metafurcal arms.

3) Tergo-Sternal Muscles

A pair of anterior tergo-sternal muscles arising on the antero-lateral portions of the tergum and inserted into the antero-lateral portions of the sternum, and a pair of posterior tergo-sternal muscles stretched between the metafurcal arms and the third phragmata are

found on the *Eutomostethus* (Fig. 41, **45, 45a**), but lacking in the two others.

4) Tergo-Pleural Muscles

The ordinary tergo-pleural muscles in the *Eutomostethus* (Fig. 41, **46, 47, 48**) are three-paired and similar to those in the mesothorax, (Fig. 41, **27, 28, 29**) respectively, except that the second tergo-pleural muscle (Fig. 41, **47**) is attached dorsally on the prealar sclerite. Those in the *Philopsyche* (Fig. 42, **41, 42**) are two-paired, the first pair are similar to the second pair in the *Eutomostethus* (Fig. 41, **47**), and the second pair (Fig. 42, **42**) are similar to the third pair in the *Eutomostethus* (Fig. 41, **48**). Those in the *Vespa* (Fig. 43, **41**) are one-paired and similar to the third pair in the *Eutomostethus* (Fig. 41, **48**) and the second pair in the *Philopsyche* (Fig. 42, **42**).

The pleuro-axillary muscles in the *Eutomostethus* (Fig. 41, **49, 50**) are two-paired, one pair arising on the apodemes on the dorsal portions of the episterna, the other on the dorsal portions of the pleural ridges, and both are attached on the third axillaries. Those in the *Philopsyche* (Fig. 42, **43**) and *Vespa* (Fig. 43, **42**) are one-paired, arising on the anterior dorsal portions of the episterna by wide bases, and attached on the third axillaries.

The pleuro-subalar muscles are found in one pair on the three species. Those in the *Eutomostethus* (Fig. 41, **51**) arise on the lower portions of the pleural ridges near the pleural coxal processes, in the *Philopsyche* (Fig. 42, **44**) on the posterior sides of the pleural arms, in the *Vespa* (Fig 43, **43**) on the upper sides of the pleural arms, all these attach on the subalar apodemes.

5) Sterno-Pleural Muscles

The sterno-basalar muscles are one-paired in the *Vespa* (Fig. 43, **44**), two-paired in the *Eutomostethus* (Fig. 41, **52, 53**), and three-paired in the *Philopsyche* (Fig. 42, **45, 46,47**). The first pair in the *Eutomostethus* (Fig. 41, **52**) and *Philopsyche* (Fig. 42, **45**) arise on the mesofurcal arms, the other pairs in both species (Fig. 4, **53**; Fig. 42, **46, 47**) and the sterno-basalar muscles in the *Vespa* (Fig. 43, **44**) arise

on the antero-lateral portions of the sternal regions, all these attach on the subalar apodemes.

The furco-entopleural muscles are two-paired in the *Eutomostethus* (Fig. 41, **54, 55**), one-paired in the *Philopsyche* (Fig. 42, **48**); the muscles in these species are similar to their methoracic furco-entopleural muscles (Fig. 41, **33, 34**; Fig. 42, **32**) respectively, except that the first pair in the first species (Fig. 41, **54**) arise laterally on the apodemes of the dorsal portions of the episterna, and that the furco-entopleural muscles in the second species (Fig, 42, **48**) laterally on the pleural arms. The furco-entopleural muscles in the *Vespa* have been displaced by chitinous bridges.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Sternal Promotors of the Coxae*

The *Eutomostethus* (Fig. 41, **56**) and *Vespa* (Fig. 43, **45**) have a strong ordinary sternal promotor arising on the furca and inserted into the anterior basal rim on each side. The *Philopsyche* has a thick anterior sternal promotor (Fig. 42, **49**) arising on the anterior marginal portion of the sternal region by a wide base and inserted into the anterior basal rim of the coxa, and an ordinary sternal promotor (Fig. 42, **50**) similar to that in the former species, on each side.

(*b*) *Coxo-Subalar Muscles*

The coxo-subalar muscles in the *Eutomostethus* (Fig. 41, **57**), *Philopsyche* (Fig. 42, **51**) and *Vespa* (Fig. 43, **46**) are very similar to those in their mesothorax.

(*c*) *Sternal Remotors of the Coxae*

The sternal remotors in the *Eutomostethus* (Fig. 41, **58**), *Philopsyche* (Fig. 42, **52**) and *Vespa* (Fig. 43, **47**) are one-paired, very thick, originated on the bases of the furcal arms and attached on the posterior basal rims of the coxae.

(*d*) *Pleural Abductors of the Coxae, and Coxo-Basalar Muscles*

The *Philopsyche* has two large fan-shaped pleural abductors on each side, one (Fig. 42, **53**) arising on the episternum, the other (Fig. 42, **54**) on the epimeron along the pleural ridge, and both are attached on the antero-lateral basal rim of the coxa. The *Vespa* has a pair of

pleural abductors (Fig. 43, 48) similar to the first pleural abductors in the former species (Fig. 42, 53).

The *Eutomostethus* lacks the pleural abductors, but has a pair of coxo-basalar muscles attached dorsally on the slender basalar apodemes and ventrally on the antero-lateral basal rims of the coxae by wide bases (Fig. 41, 59).

7) Trochanteral Muscles Arising on the Thorax

A pair of sternal depressors arising on the furcal arms and inserted into the depressor apodemes of the trochanters are found on the *Eutomostethus* (Fig. 41, 60), *Philopsyche* (Fig. 42, 55) and *Vespa* (Fig. 43, 49).

8) Muscles of the Spiracles

Each second thoracic spiracle in the three species has an occlusor. The occlusor in the *Eutomostethus* (Fig. 41, 61) and *Vespa* (Fig. 43, 50) arises on the posterior end of the epimeron of the mesothorax, in the *Philopsyche* (Fig. 42, 56) on the antero-dorsal corner of the episternum of the metathorax. In all these species the insertion is into the ventral side of the spiracle.

The thoracic muscles are tabulated below including those of some species observed by other authors.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figures 41–43 and Table XVII.

TABLE XVII

Hymenoptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the sings used in the figures; "x" shows the displacement of muscles by chitinous bridges; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Tenthredinidae. *Eutomostethus formosanus* (Fig. 41)	Tenthredinidae. *Schizocerus* sp. (WEBER, 1927)	Tenthredinidae. *Tenthredo* sp. (WEBER, 1927)	Ichneumonidae. *Philopsyche sauteri* (Fig. 42)	Vespidae. *Vespa ducalis* (Fig. 43)	Vespidae. *Vespa crabro* (WEBER, 1926)
Dorsal Muscles.						
Lateral dorsals.	—			—	3 (1) (2) (3)	1 (Idlm)
Ventral Muscles.						
Long longitudinals.	1 (1)	1 (Ovlm1)	1 (Ovlm1)	1 (1)	1 (4)	2 (Ovlm1) (Ovlm2)
Short longitudinals.	1 (2)	1 (Ovlm2)	1 (Ovlm2)	2 (2) (3)	1 (5)	—
Ventral Transverse Muscles.	1 (3)	1 (Ivlm3)	1 (Ivlm3)	—	—	—
Tergo-Pleural Muscles.						
Anterior intersegmental tergo-sternals.	2 (4) (5)	2 (Ovlm3) (Ovlm4)	1 (Ovlm3)	3 (4) (5) (6)	2 (6) (7)	1 (Oisml)
Anterior internal tergo-sternals.	1 (6)	—	—	2 (7) (8)	2 (8) (9)	1 (Ipml)
Tergo-Pleural Muscles.						
Anterior tergo-pleurals.	1 (7)	1 (Ovlm4)	—	—	1 (10)	1 (Oism2)
Ordinary tergo-pleurals.	2 (8) (9)	—	—	2 (9) (10)	3 (11) (12) (13)	5 (Ipm2) (Ipm3) (Ipm4) (Ipm5) (Ipm6)
Sterno-Pleural Muscles.						
Furco-entopleurals.	—	1 (Izm)	1 (Izm)	—	—	1 (Izm)
Coxal Muscles.						
Anterior (cervical) sternal promotors.	1 (10)			1 (11)	1 (14)	—
Ordinary sternal promotors.	1 (11)	1 (Ibml)	1 (Ibml)	1 (12)	1 (15)	1 (Ibml)
Tergal remotors.	1 (12)			1 (13)	1 (16)	1 (Ibm4)
Pleural remotors.	—			—	1 (17)	—
Posterior spinal remotors.	1 (13)			1 (14)	—	—
Ordinary sternal remotors.	2 (14) (15)	1 (Ibm2)	1 (Ibm2)	1 (15)	1 (18)	1 (a part of Ibm3)
Pleural abductors.	1 (16)	1 Ipm1, 2	1 (Ipml)	2 (16) (17)	2 (19) (20)	1 (Ibm2)
Trochanteral Muscles Arising on the Thorax.						
Pleural depressors.	1 (17)	—	—	1 (18)	1 (21)	—
Sternal depressors.	—	1 (Ibm3)	1 (Ibm3)	—	—	1 (a part of Ibm3)

b) Mesothoracic Musculature

	Tenthredinidae *Eutomostethus formosanus* (Fig. 41)	Tenthredinidae. *Schizocerus* sp. (WEBER, 1927)	Tenthredinidae. *Tenthredo* sp. (WEBER, 1927)	Ichneumonidae. *Philopsyche sauteri* (Fig. 42)	Vespidae. *Vespa ducalis* (Fig. 43)	Vespidae. *Vespa crabro* (WEBER, 1926)
Dorsal Muscles.						
Median dorsals.	3(18) (19) (20)			3(19) (20) (21)	2(22) (23)	2(IIdlm1) (IIdlm2)
Lateral dorsals.	1(21)			—	—	—
Ventral Muscles.						
Longitudinal ventrals.	2(22) (23)	2(Ivlm2) (Ivlm1)	2(Ivlm2) (Ivlm1)	2(22) (23)	2(24) (25)	3(Ivlm3) (Ivlm1) (Ivlm2)
Tergo-Sternal Muscles.						
Anterior tergo-sternals.	1(24)			1(24)	1(26)	1(IIdvm)
Posterior tergo-sternals.	2(25) (26)	1(IIisml)	—	1(25)	1(27)	1(IIism)
Tergo-Pleural Muscles.						
Ordinary tergo-pleurals.	3(27) (28) (29)			1(26)	1(28)	1(IIpm4)
Pleuro-axillary muscles.	2(30) (31)			3(27) (28) (29)	2(29) (30)	2(IIpm2) (IIpm3)
Pleuro-subalar muscles.						
Epimero-subalar (ordinary) muscles.	—	—	1(IIpm2)	—	—	—
Episterno-subalar muscles.	—	—	—	—	1(31)	1(IIpm5)
Sterno-Pleural Muscles.						
Sterno-basalar muscles.	1(32)			2(30) (31)	1(32)	1(IIpm1)
Furco-entopleural muscles.	2(33) (34)	1(IIzm)	1(IIzm)	1(32)	2(33) (34)	1(IIzm)
Coxal Muscles and Coxal Wing Muscles.						
Ordinary sternal promotors of the coxa.	1(35)	1(IIbm4)	1(IIbm4)	1(33)	1(35)	1(IIbm1)
Coxo-subalar muscles.	1(36)			1(34)	—	—
Ordinary sternal remotors of the coxa.	1(37)	2(IIbm1) (IIbm2)	2(IIbm1) (IIbm2)	1(35)	1(36)	2(IIbm2) (IIbm3)
Pleural abductors of the coxa.	1(38)	1(IIpm2)	1(IIpm1)	1(36)	—	—
Trochanteral Muscles Arising on the Thorax.						
Sternal depressors.	1(39)	1(IIbm3)	1(IIbm3)	1(37)	1(37)	1(IIbm4)
Muscles of the Spiracle.	1(40)			1(38)	1(38)	1(Istm)

c) Metathoracic Musculature

	Tenthredinidae. *Eutomostethus formosanus* (Fig. 41)	Tenthredinidae. *Schizocerus* sp. (WEBER, 1927)	Tenthredinidae. *Tenthredo* sp. (WEBER, 1927)	Ichneumonidae. *Philopsyche sauteri* (Fig. 42)	Vespidae. *Vespa ducalis* (Fig. 43)	Vespidae. *Vespa crabro* (WEBER, 1926)
Dorsal Muscles.						
Median dorsals	2(41) (42)			1(39)	1(39)	1(IIIdlm)
Lateral dorsals.	1(43)			—	—	
Ventral Muscles.						
Longitudinal ventrals.	1(44)	2(IIvlm1) (IIvlm2)	1(IIvlm1)	1(40)	1(40)	1(IIvlm)
Metaspino-metafurcal ventrals.	—	—	1(IIvlm1)	—	—	—
Tergo-Sternal Muscles.						
Anterior tergo-sternals.	1(45)			—	—	—
Posterior tergo-sternals.	1(45a)			—	—	—
Tergo-Pleural Musclss.						
Ordinary tergo-pleurals.	3(46) (47) (48)			2(41) (42)	1(41)	1(IIIpm3)
Pleuro-axillary muscles.	2(49) (50)			1(43)	1(42)	1(IIIpm2)
Pleuro-subalar muscles.	1(51)			1(44)	1(43)	2(IIIpm4)?
Sterno-Pleural Muscles.						
Sterno-basalar muscles.	2(52) (53)	1(IIism2)		3(45) (46) (47)	1(44)	1(IIIpm1)
Furco-entopleural muscles.	2(54) 2(55)			1(48)	—(x)	—(x)
Coxal Muscles and Coxal Wing Muscles.						
Anterior sternal promotors of the coxa.	—	—	—	1(49)	—	—
Ordinary sternal promotors of the coxa.	1(56)	1(IIIbm4)	1(IIIbm4)	1(50)	1(45)	1(IIIbm1)
Coxo-subalar muscles.	1(57)			1(51)	1(46)	—
Ordinary sternal remotors of the coxa.	1(58)	2(IIIbm1) (IIIbm2)	2(IIIbm1) (IIIbm2)	1(52)	1(47)	1(IIIbm2)
Pleural abductors of the coxa.	—	—	1(IIIpm1)	2(53) (54)	1(48)	—
Coxo-basalar muscles.	1(59)	—	—	—	—	—
Trochanteral Muscles Arising on the Thorax. Sternal depressors.	1(60)	1(IIIbm3)	1(IIIbm3)	1(55)	1(49)	1(IIIbm3)
Muscles of the Spiracle.	1(61)			1(56)	1(50)	1(IIstm)

d) Abdominal Musculature

		Tenthredinidae. *Eutomostethus formosanus* (Fig. 41)	Ichneumonidae. *Philopsyche sauteri* (Fig. 42)	Vespidae. *Vespa ducalis* (Fig. 43)
I Segment	Dorsal Muscles.	2 (62) (63)	2 (57) (58)	1 (51)
	Ventral Muscles.	3 (64) (65) (66)	1 (59)	2 (52) (53)
	Tergo-Sternal Muscles.	4 (67) (68) (69) (70)	—	1 (54)
	Occlusor of the Spiracle.	1 (71)	1 (60)	1 (55)
	Ventral Dilator of the Spiracle.	2 (72) (73)	1 (61)	1 (56)
II Segment	Dorsal Muscles.	4 (74) (75) (76) (77)	1 (62)	2 (57) (58)
	Dorsal Transverse Muscles.	1 (78)	—	—
	Ventral Muscles.	3 (79) (80) (81)	1 (63)	1 (59)
	Ventral Transverse Muscles.	1 (82)	1 (64)	1 (60)
	Tergo-Sternal Muscles.	5 (83) (84) (85) (86) (87)	1 (65)	1 (61)
	Occlusor of the Spiracle.	1 (88)	1 (66)	1 (62)
	Ventral Dilator of the Spiracle.	1 (89)	1 (67)	1 (63)
III Segment	Dorsal Muscles.	4 (90) (91) (92) (93)	2 (68) (69)	3 (64) (65) (66)
	Dorsal Tranrverse Muscles.	1 (94)	1 (70)	1 (67)
	Ventral Muscles.	3 (95) (96) (97)	1 (71)	3 (68) (69) (70)
	Ventral Transverse Muscles.	1 (98)	1 (72)	1 (71)
	Tergo-Sternal Muscles.	5 (99) (100) (101) (102) (103)	2 (73) (74)	1 (72)
	Occlusor of the Spiracle.	1 (104)	1 (75)	1 (73)
	Ventral Dilator of the Spiracle.	1 (105)	—	1 (74)
IV–VI Segments	Dorsal Muscles.	3 (106) (107) (108)	2 (76) (77)	3 (64) (65) (66)
	Dorsal Transverse Muscles.	1 (109)	1 (78)	1 (67)
	Ventral Muscles.	3 (110) (111) (112)	—	3 (68) (69) (70)
	Ventral Transverse Muscles.	1 (113)	1 (79)	1 (71)
	Tergo-Sternal Muscles.	5 (114) (115) (116) (117) (118)	2 (80) (81)	2 (72) (75)
	Occlusor of the Spiracle.	1 (119)	1 (82)	1 (73)
	Ventral Dilator of the Spiracle.	1 (120)	—	1 (74)

17. DIPTERA

Tipulidae. *Ctenacroscelis mikado* WESTWOOD (Fig. 44)
Stratiomyidae. *Pecticus latifascia* WALKER (Fig. 45)
Syrphidae. *Lathyrophthalmus obscuritarsis* DE MEIJERE (Fig. 46)
Micropezidae. *Calobata sinensis* ENDERLEIN (Fig. 47)
Muscidae. *Orthellia claripennis* MALL (Fig. 48)

a. Prothoracic Musculature

1) Dorsal Muscles

The dorsal muscles divide into median dorsals and lateral dorsals. The median dorsals are one-paired in the *Ctenacroscelis mikado* (Fig. 44, **1**), *Pecticus latifascia* (Fig. 45, **1**), *Lathyrophthalmus obscuritarsis* (Fig. 46, **1**), *Calobata sinensis* (Fig. 47, **1**) and *Orthellia claripennis* (Fig. 48, **1**). Those in the first, second and fourth species arise on the dorso-lateral cervical sclerites immediately behind the head, in the third species on the dorso-lateral membranes, in the last species on the dorso-lateral portions of the posterior end of the head. Those in all these species take the insertions into the first phragmata.

The lateral dorsals in the *Pecticus* (Fig. 45, **2**, **3**), *Lathyrophthalmus* (Fig. 46, **2**, **3**), *Calobata* (Fig. 47, **2**, **3**) and *Orthellia* (Fig. 48, **2**, **3**) are two-paired. Those in the *Pecticus* and *Orthellia* arise on the dorso-lateral cervical sclerites or on the dorso-lateral portions of the posterior end of the head and attach on the antero-lateral corners of the mesotergum; the first lateral muscles in the *Lathyrophthalmus* (Fig. 46, **2**) and *Calobata* (Fig. 47, **2**) arise on the dorso-lateral cervical membranes (the former) or on the dorso-lateral cervical sclerites (the latter) and attach on the antero-lateral corners of the mesotergum, the second ones in the *Lathyrophthalmus* (Fig. 46, **3**) and *Calobata* (Fig. 47, **3**) are short, arise on the transverse ridges of the postero-lateral tergal regions (the former) or on the outsides of the first phragmata (the latter), and attach on the antero-lateral regions of the tergum.

2) Ventral Muscles

The ventral muscles are divisible into three kinds, long internal ventrals, median external ventrals and lateral external ventrals. The

long internal ventrals in the *Ctenacroscelis* (Fig. 44, **2**), *Pecticus* (Fig. 45, **4**) and *Lathyrophthalmus* (Fig. 46, **4**) are one-paired, those in the *Calobata* (Fig. 47, **4, 5, 6**) and *Orthellia* (Fig. 48, **4, 5, 6**) are three-paired. These long internal ventrals arise on the ventro-lateral portions of the posterior end of the head by slender tendons and attach on the furcal arms by wide bases. The lateral or ordinary external ventrals in the *Ctenacroscelis* (Fig. 44, **3**), *Pecticus* (Fig. 45, **5**), *Lathyrophthalmus* (Fig. 46, **5**), *Calobata* (Fig. 47, **7**) and *Orthellia* (Fig, 48, **7**) are one-paired, take their origins on the posterior portions of the ventro-lateral cervical sclerites and their insertions into the furcal arms. The median external ventral muscles are very slender, attached posteriorly on the furcal arms and anteriorly on the ventral region of the prothorax or the cervicum in various situations: Those in the *Ctenacroscelis* (Fig. 44, **4**) attach on the anterior apophysis on the main sternal plate, in the *Lathyrophthalmus* (Fig. 46, **6**) on the anterior margin of the main sternite near the ventral median line, in *Calobata* (Fig. 47, **8**) on the lateral margins of the main sternite, in the *Orthellia* (Fig. 48, **8**) on the posterior end of the ventral median cervical sclerite.

3) Ventral Transverse Muscles

A pair of very fine ventral transverse muscles arising on the furcal arms, diverging, and joining in the formation of a delicate common net of ventral transverse musclcs are found on the *Ctenacroscelis* (Fig. 44, **5**).

4) Tergo-Sternal Muscles

There are four kinds of tergo-sternal muscles, anterior intersegmentals, anterior internals, anterior externals, and posteriors. The anterior intersegmental tergo-sternals in the *Pecticus* (Fig. 45, **6**) are one-paired, in the *Calobata* (Fig. 47, **9, 10**) and *Orthellia* (Fig. 48, **9, 10**) are two-paired, in the *Ctenacroscelis* (Fig, 44, **6, 7, 8**) are three-paired, in the *Lathyrophthalmus* (Fig. 46, **7, 8, 9, 10**) are four-paired; these are attached dorsally on tne dorso-lateral portions of the posterior end of the head (*Ctenacroscelis, Lathyrophthalmus, Orthellia*) or on the dorso-lateral cervical sclerites (*Ctenacroscelis, Pecticus, Calo-*

bata), and ventrally on the middle (*Ctenacroscelis*) or posterior (the four other species) portions of the ventro-lateral cervical sclerites.

The anterior internal tergo-sternal muscles are one-paired in the *Lathyrophthalmus* (Fig. 46, **11**), *Calobata* (Fig. 47, **11**) and *Orthellia* (Fig. 48, **11**), and two-paired in the *Pecticus* (Fig. 45, **7**, **8**); these, though the first pair in the *Pecticus* (Fig. 45, **7**) arise on the anterior median region of the tergum exceptionally, are originated on the posterior dorso-lateral regions of the tergum and inserted into the insides of the middle regions of the ventro-lateral cervical sclerites.

The anterior external tergo-sternal muscles are one-paired in the *Lathyrophthalmus* (Fig. 46, **12**), *Calobata* (Fig. 47, **12**) and *Orthellia* (Fig. 48, **12**), and two-paired in the *Pecticus* (Fig. 45, **9**, **10**); the first pair in the last species (Fig. 45, **9**) arise on the anterior portions of the dorso-lateral regions of the tergum by wide bases, the second pair (Fig. 45, **10**) on the antero-lateral corners of the mesotergum, both attach on the postero-lateral corners of the ventro-lateral cervical sclerites. The anterior external tergo-sternals in the first three species arise on the anterior ends of the dorso-lateral or the lateral regions of the tergum, and attach to the postero-lateral corners of the ventro-lateral cervical sclerites.

The posterior tergo-sternal muscles are very slender, found in a pair on the *Ctenacroscelis* (Fig. 44, **9**). They arise on the notaulices of the mesotergum and attach to the profurcal arms.

5) Tergo-Pleural Muscles

On each side of the *Ctenacroscelis* there is a broad tergo-pleural muscle arising on the dorso-lateral portion of the transverse tergal ridge and attached on the antero-dorsal portion of the pleuron (Fig. 44, **9**).

6) Coxal Muscles

(*a*) *Sternal Promotors of the Coxae*

Two kinds of sternal promotors of the coxae are found on the prothorax, anterior cervical promotors and ordinary sternal promotors. The anterior cervical sternal promotors are muscles originating on the posterior ends of the ventro-lateral cervical sclerites and attached on

the anterior basal rims of the coxae; these are one-paired in the *Pecticus* (Fig. 45, **11**), *Calobata* (Fig. 47, **13**), *Orthellia* (Fig. 48, **13**), and two-paired in the *Lathyrophthalmus* (Fig. 46, **13, 14**), but lacking in the *Ctenacroscelis*.

The ordinary sternal promotors in the *Ctenacroscelis* (Fig. 44, **11**), *Pecticus* (Fig. 45, **12**), *Calobata* (Fig. 47, **14**) and *Orthellia* (Fig. 48, **14**) are one-paired, strong, fan-shaped, arising on the median ridge of the main sternal region by wide bases and attached to the anterior basal rims of the coxae. Those in the *Lathyrophthalmus* are two-paired, the first pair (Fig. 46, **15**) are very similar to the ordinary sternal promotors in the four former species, the second (Fig. 46, **16**) arise on the furcal arms and are attached to the anterior basal rims of the coxae.

(*b*) *Pleural Remotors of the Coxae*

On each side of the *Calobata* (Fig. 47, **15**) and *Orthellia* (Fig. 48, **15**) there is a strong pleural remotor arising on the anterior portion of the mesothoracic episternal region behind the first thoracic spiracle by a wide base and attached on the posterior basal rim of the coxa. The *Ctenacroscelis*, *Pecticus* and *Lathyrophthalmus* lack the pleural remotor.

(*c*) *Sternal Remotors of the Coxae*

The *Ctenacroscelis* (Fig. 44, **12**), *Pecticus* (Fig. 45, **13**), *Lathyrophthalmus* (Fig. 46, **17**) and *Orthellia* (Fig. 48, **16**) have a sternal remotor arising on the furcal arm and attached on the posterior basal rim of the coxa, and the *Calobata* (Fig. 47, **16, 17**) has two sternal remotors, one arising on the outside of the base of the furcal arm by a wide base and attached on the posterior basal rim of the coxa, the other similar to the sternal remotor in the four former species, on each side.

(*d*) *Pleural Abductors of the Coxae*

The *Ctenacroscelis* (Fig. 44, **13, 14**) and *Pecticus* (Fig. 45, **14, 15**) have two pleural abductors, and the *Lathyrophthalmus* (Fig. 46, **18**), *Calobata* (Fig. 47, **18**) and *Orthellia* (Fig. 48, **17**) have a pleural abductor, on each side; these arise on the tergo-pleural regions by wide bases and attach on the antero-lateral basal rims of the coxae.

7) Trochanteral Muscles Arising on the Thorax

(*a*) *Tergal Depressors of the Trochanters*

The trochanter of the *Pecticus* (Fig. 45, **16**), *Lathyrophthalmus* (Fig. 46, **19**) and *Orthellia* (Fig. 48, **18**) has a tergal depressor arising on the lateral region of the tergum and inserted into the depressor apodeme of its own ventral base. In that of the *Ctenacroscelis* and *Calobata* it is absent.

(*b*) *Pleural Depressors of the Trochanters*

The *Ctenacroscelis* (Fig. 44, **15, 16**) has two pleural depressors, one arising on the episternum, the other on the epimeron, and the *Pecticus* (Fig. 45, **17**) and *Calobata* (Fig. 47, **19**) have a pleural depressor arising on the anterior side of the pleural arm, on each side; these attach on the depressor apodemes of the ventral bases of the trochanters.

(*c*) *Sternal Depressors of the Trochanters*

A sternal depressor stretched between the furcal arm and the depressor apodeme of the trochanter is found on each side of the *Ctenacroscelis* (Fig. 44, **17**), *Pecticus* (Fig. 45, **18**), *Lathyrophthalmus* (Fig. 46, **20**) and *Orthellia* (Fig. 48, **19**). As far as the writer observed, the sternal depressors were not found on the *Calobata*.

b. Mesothoracic Musculature

1) Dorsal Muscles

The *Ctenacroscelis* (Fig. 44, **18, 19**), *Pecticus* (Fig. 45, **19, 20**), *Lathyrophthalmus* (Fig. 46, **21, 22**) and *Calobata* (Fig. 47, **20, 21**) have two pairs of dorsal muscles, median and lateral; the median pair are very thick, stretched between the anterior portion of the tergum and the second phragmata, very often divided into several bundles; the lateral pair are oblique, arising on the scutum before the scutellum and attached on the lateral portions of the second phragmata. The dorsal muscles in the *Orthellia* (Fig. 48, **20, 21, 22**) are similar to those in the former species, but the median dorsal muscles are usually subdivided into internals (Fig. 48, **20**) and externals (Fig. 48, **21**).

2) Ventral Transverse Muscles

On the *Ctenacroscelis* are found two pairs of ventral transverse muscles, anterior and posterior; the anterior pair (Fig; 44, **20**) arise on the intersegmental ridges at the anterior ends of the episterna, the posterior pair (Fig. 44, **21**) originate on the furcal arms. Both join to the formation of a common delicate net of ventral transverse muscles. The four other species lack the ventral transverse muscles.

3) Tergo-Sternal Muscles

The *Ctenacroscelis* (Fig. 44, **22**), *Pecticus* (Fig. 45, **21**), *Lathyrophthalmus* (Fig. 46, **23**), *Calobata* (Fig. 47, **22**) and *Orthellia* (Fig. 48, **23**) have a very thick anterior tergo-sternal muscle arising on the lateral portion of the tergum anterior to the scutal transverse ridge and inserted into the ventral region of the segment near the ventral median ridge, on each side.

4) Tergo-Pleural Muscles

In the tergo-pleural muscles there are two kinds, ordinary tergo-pleural muscles and pleuro-axillary muscles. The ordinary tergo-pleural muscles in the *Ctenacroscelis* (Fig. 44, **23, 24, 25**), *Pecticus* (Fig. 45, **22, 23, 24**), *Lathyrophthalmus* (Fig. 46, **24, 25, 26**), *Calobata* (Fig. 47, **23, 24, 25**) and *Orthellia* (Fig. 48, **24, 25, 26**) are three-paired: The first pair arise on the insides of the anterior notal wing processes, exceptionally on the anterior notal wing processes in the *Ctenacroscelis* (Fig. 44, **23**), and are inserted into the ventral portions of the basalar invaginations; the second on the antero-lateral margins of the tergum and into the anterior portions of the basalar invaginations; the third on the lateral ends of the scutal transverse ridges at the anterior sides of the anterior notal wing processes, and into the dorsal portions of the episterna immediately forward the pleural wing processes, exceptionally into the pleural ridges in the *Pecticus* (Fig. 45, **24**).

The pleuro-axillary muscles are well-developed. These are divisible into three kinds, muscles of the first, third and fourth axillary. The *Ctenacroscelis* (Fig. 44. **26, 27**), *Pecticus* (Fig. 45, **25, 26**), *Lathyrophthalmus* (Fig. 46, **27, 28**), *Calobata* (Fig. 47, **26, 27**) and *Orthellia* (Fig. 48, **27, 28**) have two fan-shaped muscles of the first axillary on

each side, one arising on the episternal region, often along the horizontal episterno-precoxal ridge, by a wide base, the other on the pleural arm by a wide base, both are attached on the first axillary sclerite by tendons or a common tendon. Two muscles of the third axillary are found on each side of the *Ctenacroscelis* (Fig. 44, **28, 29**), *Pecticus* (Fig. 45, **27, 28**), *Calobata* (Fig. 47, **28, 29**) and *Orthellia* (Fig. 48, **29, 30**), one arising on the episternum by a broad base, the other on the epimeron along the pleural ridge by a wide base, both are inserted into the third axillary by a common apodeme. The muscles of the third axillary in the *Lathyrophthalmus* (Fig. 46, **29, 30, 31**) are similar to those in the four others, but the epimeral bundles (Fig. 46, **30, 31**) are two-paired. The muscles of the fourth axillary in the *Ctenacroscelis* (Fig. 44, **30, 31**) and *Lathyrophthalmus* (Fig. 46, **32, 33**) are two-paired and arise on the pleural arms or ridges by wide bases, those in the *Pecticus* (Fig. 45, **29, 30, 31**) and *Calobata* (Fig. 47, **30, 31, 32**) are three-paired and originate on the pleural arms or the epimera immediately behind the pleural arms; those in the *Orthellia* (Fig. 48, **31, 32, 33, 34**) are four-paired, one pair arising on the pleural ridges, the other on the epimera, two remainders arise on the lower portions of the pleural ridges; all these attach on the fourth axillary sclerites by tendons.

5) Sterno-Pleural Muscles

The *Pecticus*, *Lathyrophthalmus*, *Calobata* and *Orthellia* have a pair of fan-shaped sterno-basalar muscles and two pairs of furco-entopleural muscles (Fig. 45, **32, 33, 34**; Fig. 46, **34, 35, 36**; Fig. 47, **33, 34, 35**; Fig. 48, **35, 36, 37**). The sterno-basalar muscles in the *Pecticus* arise on the anterior ends of the ventro-lateral regions of the segment, those in the three others on the so-called opisterno-precoxal ridges; all these attach dorsally on the basalar invaginations. The first or dorsal pair of furco-entopleural muscles are stretched between the pleural arms and the furcal arms. The second or ventral pair of furco-entopleural muscles arise on the furcal arms by wide bases and are attached to the lower portions of the pleural ridges by slender tendons. The *Ctenacroscelis* has a pair of sterno-basalar muscles

(Fig. 44, **32**) similar to those in the *Pecticus*, and a pair of furco-entopleural muscles (Fig. 44, **33**) similar to the dorsal furco-entopleural muscles in the four others.

6) Coxal Muscles and Coxal Wing Muscles

(*a*) *Sternal Promotors of the Coxae*

The sternal promotors in the *Ctenacroscelis* (Fig. 44, **35**), *Pecticus* (Fig, 45, **35**), *Lathyrophthalmus* (Fig. 46, **37**) and *Calobata* (Fig. 47, **36**) are one-paired, arising on the furca by wide bases. Those in the *Orthellia* are two-paired, one pair (Fig. 48, **38**) arising on the sternal wall at both sides of the sternal median ridge, the other (Fig. 48, **39**) on the furca. All these attach on the anterior basal rims of the coxae.

(*b*) *Tergal Remotors of the Coxae*

A very thick muscle arising on the lateral portion of the tergum behind the scutal transverse ridge and inserted into the meron or the meropleurite is found on each side of the *Ctenacroscelis* (Fig. 44, **36**), *Pecticus* (Fig. 45, **36**), *Lathyrophthalmus* (Fig. 46, **38**), *Calobata* (Fig. 47, **37**) and *Orthellia* (Fig. 48, **40**). This is a muscle homologous to the tergal remotor of the coxa in the other lower insects.

(*c*) *Coxo-Subalar Muscles*

On each side of the *Ctenacroscelis* (Fig. 44, **37**) is found a very thick coxo-subalar muscle arising on the lateral portion of the meron and attached on the subalar invagination. The four other species lack it.

(*d*) *Sternal Remotors of the Coxae*

The *Pecticus* (Fig. 45, **37**), *Lathyrophthalmus* (Fig. 46, **39**), *Calobata* (Fig. 47, **38**) and *Orthellia* (Fig. 48, **41**) have a sternal remotor arising on the furca and attached on the posterior rim of the coxa on each side. The *Ctenacroscelis* has a sternal remotor (Fig. 44, **38**) similar to that in the four others, and a sternal remotor (Fig. 44, **34**) arising on the furcal arm and attached on the lateral portion of the meron by a tendon, on each side.

7) Trochanteral Muscles Arising on the Thorax

(*a*) *Depressors*

The *Pecticus* (Fig. 45, **38**, **39**), *Lathyrophthalmus* (Fig. 46, **40**, **41**),

Calobata (Fig, 47, **39, 40**) and *Orthellia* (Fig. 48, **42, 43**) have a pair of tergal depressors arising on the lateral portions of the tergum behind the scutal transverse ridges and inserted into the common depressor apodemes of the ventral bases of the trochanters, and a pair of sternal depressors arising on the furcal arms and attached on the common depressor apodemes as the former, but lacking the pleural depressors.

The *Ctenacroscelis* has a pair of pleural depressors (Fig. 44, **39**) arising on the episternal regions beneath the ventral ends of the pleuro-axillary muscles (Fig. 44, **26**) and attached on the ventral ends of the trochanters by the common depressor apodemes, and a pair of sternal depressors (Fig. 44, **40**) similar to those in the four other species, but lacking the tergal depressors.

(*b*) *Levators*

The *Pecticus* (Fig. 45, **40**), *Lathyrophthalmus* (Fig. 46, **41**), *Calobata* (Fig. 47, **41**) and *Orthellia* (Fig. 48, **44**) have a pair of pleural levators of the trochanters arising on the apodemes at the ventral ends of the pleural ridges and inserted into the dorsal bases of the trochanters by the levator tendons, but the *Ctenacroscelis* lacks the pleural levators. The pleural levators in the four former species are probably homologous to the coxal levators of the trochanters in the *Ctenacroscelis* (Fig. 44, **41**).

8) **Muscles of the Spiracles**

The five species have an occlusor on each first thoracic spiracle. The occlusor in the *Ctenacroscelis* (Fig. 44, **42**) and *Pecticus* (Fig. 45, **41**) originates on the intersegmental ridge at the anterior end of the pleuron, in the *Lathyrophthalmus* (Fig. 46, **43**), *Calobata* (Fig. 47, **42**) and *Orthellia* (Fig. 48, **45**) on the upper side of the propleural arm, these each take the insertion into the under side of the spiracle.

c. Metathoracic Musculature

1) **Dorsal Transverse Muscles**

A pair of delicate dorsal transverse muscles arising on the posterior side of the second phragmata and attached on the dorsal vessel

are found on the *Ctenacroscelis* (Fig. 44, **43**), *Pecticus* (Fig. 45, **42**), *Lathyrophthalmus* (Fig. 46, **44**), *Calobata* (Fig. 47, **43**) and *Orthellia* (Fig. 48, **46**).

2) Ventral Muscles

The *Ctenacroscelis* (Fig. 44, **44**), *Lathyrophthalmus* (Fig. 46, **45**), *Calobata* (Fig. 47, **44**) and *Orthellia* (Fig. 48, **47**) have a pair of longitudinal ventral muscles, and the *Pecticus* (Fig. 45, **43, 44**) has two pairs of longitudinal ventral muscles; these muscles are stretched between the meso- and metafurca.

3) Ventral Transverse Muscles

The *Ctenacroscelis* (Fig. 44, **45**) has a pair of very fine posterior ventral transverse muscles similar to those in the mesothorax. The four other species lack the ventral transverse muscles.

4) Tergo-Sternal Muscles

A pair of slender anterior tergo-sternal muscles attached ventrally on the antero-lateral portions of the sternum and dorsally on the lateral portions of the tergum inside the processes corresponding to the anterior notal wing processes are found on the five species (Fig. 44, **46**; Fig. 45, **45**; Fig. 46, **46**; Fig. 47, **45**; Fig. 48, **48**).

5) Tergo-Pleural Muscles

The ordinary tergo-pleural muscles are found in two pairs on the *Ctenacroscelis* (Fig. 44, **47, 48**), *Pecticus* (Fig. 45, **46, 47**), *Lathyrophthalmus* (Fig. 46, **47, 48**), *Calobata* (Fig. 47, **46, 47**) and *Orthellia* (Fig. 48, **49, 50**). In the first species, the first pair (Fig. 44, **47**) arise on the lateral portions of the tergum inside the processes corresponding to the anterior notal wing processes, and are inserted into the anterior margins of the dorsal portions of the episterna, the second (Fig. 44, **48**) on the processes corresponding to the posterior notal wing processes and into the pleural ridges. In the four other species, the first pair arise on the lateral portions of the second phragmata and are inserted into the dorso-anterior portions of the episterna, the second on the lateral portions of the tergum inside the processes corresponding to the anterior notal wing processes and into the pleural ridges.

Halter muscles corresponding to the pleuro-axillary muscles in the

mesothorax are found in one pair on the *Ctenacroscelis* (Fig. 44, **49**), *Pecticus* (Fig. 45, **48**), *Lathyrophthalmus* (Fig. 46, **49**), *Calobata* (Fig. 47, **48**), and *Orthellia* (Fig. 48, **51**). These are very small, arising on the dorsal portions of the pleural ridges, and attached to the small sclerites situated on the posterior bases of the halters and probably corresponding to the third axillary sclerites.

Halter muscles corresponding to the pleuro-subalar muscles are found in one pair on the *Pecticus* (Fig. 45, **49**), *Lathyrophthalmus* (Fig. 46, **50**), *Calobata* (Fig. 47, **49**) and *Orthellia* (Fig. 48, **52**). Those in the first species arise on the dorsal portions of the pleural ridges, those in the last three species on the posterior sides of the ventral pleural arms, all these attach on the small sclerites corresponding to the subalar sclerites at the posterior bases of the ventral sides of the halters.

6) Sterno-Pleural Muscles

A pair of halter muscles corresponding to the sterno-basalar muscles, arising on the ventro-lateral portions of the intersegmental ridge between the meso- and metathorax and attached on the anterior margins of the dorsal portions of the episterna are found on the *Ctenacroscelis* (Fig. 44, **50**), *Pecticus* (Fig. 45, **50**), *Lathyrophthalmus* (Fig. 46, **51**), *Calobata* (Fig. 47, **50**) and *Orthellia* (Fig. 48, **53**).

The furco-entopleural muscles in the *Ctenacroscelis* (Fig. 44, **51**, **52**), *Pecticus* (Fig. **51**, **52**), *Lathyrophthalmus* (Fig. 46, **52**, **53**), *Calobata* (Fig. 47, **51**, **52**) and *Orthellia* (Fig. 48, **54**, **55**) are very similar to those in their mesothorax.

7) Coxal Muscles and Coxal Halter Muscles

(*a*) *Sternal Promotors of the Coxae*

The sternal promotors in the *Ctenacroscelis* (Fig. 44, **53**), *Pecticus* (Fig. 45, **53**), *Lathyrophthalmus* (Fig. 46, **54**), *Calobata*, (Fig. 47, **53**) and *Orthellia* (Fig. 48, **56**) are very similar to the mesothoracic sternal promotors.

(*b*) *Coxo-Subalar Muscles*

On the *Ctenacroscelis* (Fig. 44, **54**) are found a pair of coxo-sub alar muscles arising on the postero-lateral basal rims of the coxae and

inserted into the sclerites corresponding to the subalar sclerites in the mesothorax. The four other species lack the coxo-subalar muscles.

(*c*) *Sternal Remotors of the Coxae*

The sternal remotors in the *Ctenacroscelis* (Fig. 44, 55), *Pecticus* (Fig. 45, 54), *Lathyrophthalmus* (Fig. 46, 55), *Calobata* (Fig. 47, 54) and *Orthellia* (Fig. 48, 57) resemble those in their mesothorax.

(*d*) *Pleural Abductors of the Coxae*

The *Ctenacroscelis* (Fig. 44, 56), *Lathyrophthalmus* (Fig. 46, 56), *Calobata* (Fig. 47, 55) and *Orthellia* (Fig. 48, 58) are provided with a pair of pleural abductors arising on the episterna and attached on the antero-lateral basal rims of the coxae. The *Pecticus* has no pleural abductor.

8) Trochanteral Muscles Arising on the Thorax

(*a*) *Depressors*

The *Pecticus* (Fig. 45, 55), *Calobata* (Fig. 47, 56) and *Orthellia* (Fig. 48, 59) have a pair of tergal depressors arising on the postero-lateral portions of the tergum, the *Ctenacroscelis* (Fig. 44, 57, 58, 59) has three pairs of pleural depressors, one pair arising on the dorsal narrow portions of the episterna, the other on the broad portions of the episterna, still an other on the pleural ridges; the *Ctenacroscelis* (Fig. 44, 60), *Lathyrophthalmus* (Fig. 46, 57), *Calobata* (Fig. 47, 57), *Orthellia* (Fig. 48, 60) have a pair of sternal depressors arising on the furcal arms, the *Pecticus* (Fig. 45, 56, 57) has two pairs of the sternal depressors, one pair similar to the sternal depressors in the four other species, the other arising on the mesofurcal arms; all the depressors attach to the common depressor apodemes of the ventral bases of the trochanters.

(*b*) *Levators*

On each side of the *Ctenacroscelis* (Fig. 44, 61), *Pecticus* (Fig. 45, 58), *Lathyrophthalmus* (Fig. 46, 58), *Calobata* (Fig. 47, 58) and *Orthellia* (Fig. 48, 61) is found a levator arising on the ventral pleural arm and inserted into the dorsal base of the trochanter by a tendon.

9) Muscles of the Spiracles

An occlusor is found on each second thoracic spiracle. That in

TABLE XVIII

Diptera

(Nonbracketted numerals show the number of muscles; bracketted numerals and letters show the signs used in the figures; "—" shows the absence of muscles)

a) Prothoracic Musculature

	Tipulidae. *Ctenacroscelis mikado* (Fig. 44)	Stratiomyidae. *Pecticus latifascia* (Fig. 45)	Syrphidae. *Lathyrophthalmus obscuritarsis* (Fig. 46)	Syrphidae. *Volucella zonaria* (BERLESE, 1909)	Micropezidae. *Calobata sinensis* (Fig. 47)	Muscidae. *Orthellia claripennis* (Fig. 48)
Dorsal Muscles.						
Median dorsals.	1 (1)	1 (1)	1 (1)	1(140)	1 (1)	1 (1)
Lateral dorsals.	—	2 (2) (3)	2 (2) (3)	—	2 (2) (3)	2 (2) (3)
Ventral Muscles.						
Internal ventrals.	1 (2)	1 (4)	1 (4)	1(137)	3 (4) (5) (6)	3 (4) (5) (6)
External ventrals.						
Lateral (ordinary ex. v.)	1 (3)	1 (5)	1 (5)	1(135)	1 (7)	1 (7)
Medians.	1 (4)	—	1 (6)	—	1 (8)	1 (8)
Ventral Transverse Muscles.	1 (5)	—	—	—	—	—
Tergo-Sternal Muscles.						
Anterior intersegmental tergo-sternals.	3 (6) (7) (8)	1 (6)	4 (7) (8) (9) (10)	2(146) (147)	2 (9) (10)	2 (9) (10)
Anterior internal tergo-sternals.	—	2 (7) (8)	1(11)	1(144)?	1(11)	1(11)
Anterior external tergo-sternals.	—	2 (9) (10)	1(12)	—	1(12)	1(12)
Posterior tergo-sternals.	1 (9)	—	—	—	—	—
Tergo-Pleural Muscles.						
Ordinary tergo-pleurals.	1(10)	—	—		—	—
Coxal Muscles.						
Pleural promotors.	—	—	—	1(CXXV)?	—	—
Anterior (cervical) sternal promotors	—	1(11)	2(13) (14)	1(CXXVI)	1(13)	1(13)
Ordinary sternal promotors.	1(11)	1(12)	2(15) (16)	2(CXXVIa) (CXXVIb)	1(14)	1(14)
Pleural remotors.	—	—	—		1(15)	1(15)
Ordinary sternal remotors.	1(12)	1(13)	1(17)	1(129)	2(16) (17)	1(16)
Pleural abductors.	2(13) (14)	2(14) (15)	1(18)	1(CXXII)	1(18)	1(17)
Trochanteral Muscles Arising on the Thorax.						
Tergal depressors.	—	1(16)	1(19)	1(CXXIV)	—	1(18)
Pleural depressors.	2(15) (16)	1(17)	—	—	1(19)	—
Sternal depressors.	1(17)	1(18)	1(20)	1(130)	—	1(19)

b) Mesothoracic Musculature

	Tipulidae. *Ctenacroscelis mikado* (Fig. 44)	Stratiomyidae. *Pecticus latifascia* (Fig. 45)	Syrphidae. *Lathyrophthalmus obscuritarsis* (Fig. 49)	Syrphidae. *Volucella zonaria* (BERLESE, 1909)	Micropezidae. *Calobata sinensis* (Fig. 47)	Muscidae. *Orthellia claripennis* (Fig. 48)
Dorsal Muscles.						
Median dorsals.	1(18)	1(19)	1(21)	1(69+70)	1(20)	2(20) (21)
Lateral dorsals.	1(19)	1(20)	1(22)	1(71)	1(21)	1(22)
Ventral Muscles (?)	—	—	—	1(105+106)	—	—
Ventral Transverse Muscles.						
Anteriors.	1(20)	—	—	—	—	—
Posteriors.	1(21)	—	—	—	—	—
Tergo-Sternal Muscles.						
Anterior tergo-sternals.	1(22)	1(21)	1(23)	1(LXXVII)	1(22)	1(23)
Tergo-Pleural Muscles.						
Ordinary tergo-pleurals.	3(23) (24) (25)	3(22) (23) (24)	3(24) (25) (26)	3(XCIa) (XCI) (XCIII)	3(23) (24) (25)	2(24) (25) (26)
Pleuro-axillary muscles.						
Muscles of the 1st axillary.	2(26) (27)	2(25) (26)	2(27) (28)	2(XCVII) (XCV)	2(26) (27)	2(27) (28)
Muscles of the 3rd axillary.	2(28) (29)	2(27) (28)	3(29) (30) (31)	2(CI) (CIa)	2(28) (29)	2(29) (30)
Muscles of the 4th axillary.	3(30) (31)	3(29) (30) (31)	2(32) (33)	2(LXXVIII)? (85a)	3(30) (31) (32)	4(31) (32) (33) (34)
Sterno-Pleural Muscles.						
Sterno-basalar muscles.	1(32)	1(32)	1(34)	2(CII) (CIIa)	1(33)	1(35)
Furco-entopleural muscles.	2(33)	2(33) (34)	2(35) (36)	2(100) (100a)	2(34) (35)	2(36) (37)
Coxal Muscles and Coxal Wing Muscles.						
Ordinary sternal promotors of the coxa.	1(35)	1(35)	1(37)	2(93) (98)	1(36)	2(38) (39)
Tergal remotors of the coxa.	1(36)	1(36)	1(38)	1(LXXVII)	1(37)	1(40)
Coxo-subalar muscles.	1(37)	—	—	—	—	—
Ordinary sternal remotors of the coxa.	2(38) (34)	1(37)	1(39)	1(97)	1(38)	1(41)
Trochanteral Muscles Arising on the Thorax.						
Tergal depressors.	—	1(38)	1(40)	1(76)	1(39)	1(42)
Pleural depressors.	1(39)	—	—	—	—	—
Sternal depressors.	1(40)	1(39)	1(41)	1(96)	1(40)	1(43)
Pleural levators.	—	1(40)	1(42)		1(41)	1(44)
Muscles of the Spiracle.	1(42)	1(41)	1(43)		1(42)	1(45)

c) Metathoracic Musculature

	Tipulidae. *Ctenacroscelis mikado* (Fig. 44)	Stratiomyidae. *Pecticus latifascia* (Fig. 45)	Syrphidae. *Lathyrophthalmus obscuritarsis* (Fig. 46)	Micropezidae. *Calobata sinensis* (Fig. 47)	Muscidae. *Orthellia claripennis* (Fig. 48)
Dorsal Transverse Muscles.	1(43)	1(42)	1(44)	1(43)	1(46)
Ventral Muscles. Longitudinal ventrals.	1(44)	2(43) (44)	1(45)	1(44)	1(47)
Ventral Transverse Muscles. Posteriors.	1(45)	—	—	—	—
Tergo-Sternal Muscles. Anterior tergo-sternals.	1(46)	1(45)	1(46)	1(45)	1(48)
Tergo-Pleural Muscles. Ordinary tergo-pleurals.	2(47) (48)	2(46) (47)	2(47) (48)	2(46) (47)	2(49) (50)
Halter muscles corresponding to the mesothoracic pleuro-axillary muscles.	1(49)	1(48)	1(49)	1(48)	1(51)
Halter muscles corresponding to the mesothoracic pleuro-subalar muscles.	—	1(49)	1(50)	1(49)	1(52)
Sterno-Pleural Muscles. Halter muscles corresponding to the mesothoracic sterno-basalar muscles.	1(50)	1(50)′	1(51)	1(50)	1(53)
Furco-entopleural muscles.	1(51) (52)	2(51) (52)	2(52) (53)	2(51) (52)	2(54) (55)
Coxal Muscles and Coxal Halter Muscles. Ordinary sternal promotors of the coxa.	1(53)	1(53)	1(54)	1(53)	1(56)
Coxal halter muscles corresponding to the mesothoracic coxo-subalar muscles.	1(54)	—	—	—	—
Ordinary sternal remotors of the coxa.	1(55)	1(54)	1(55)	1(54)	1(57)
Pleural abductors of the coxa.	1(56)	—	1(56)	1(55)	1(58)
Trochanteral Muscles Arising on the Thorax. Tergal depressors.	—	1(55)	—	1(56)	1(59)
Pleural depressors.	3(57) (58) (59)	—	—	—	—
Sternal depressors.	1(60)	1(56)	1(57)	1(57)	1(60)
Mesofurcal depressors.	—	1(57)	—	—	—
Pleural levators.	1(61)	1(58)	1(58)	1(58)	1(61)
Muscles of the Spiracle.	1(62)	1(59)	1(59)	1(59)	1(62)

d) Abdominal Musculature

	Tipulidae. *Ctenacroscelis mikado* (Fig. 44)	Stratiomyidae. *Pecticus latifascia* (Fig. 45)	Syrphidae. *Lathyrophthalmus obscuritarsis* (Fig. 46)	Micropezidae. *Calobata sinensis* (Fig. 47)	Muscidae. *Orthellia claripennis* (Fig. 48)
I Segment					
Dorsal Muscles.	3(63) (64) (65)	1(60)	2(60) (61)	2(60) (61)	3(63) (64)
Dorsal Transverse Muscles.	—	—	—	—	1(65)
Ventral Muscles.	1(66)	1(61)	1(62)	1(62)	2(66) (67)
Ventral Transverse Muscles.	2(67) (68)	—	—	—	—
Tergo-Sternal Muscles.	1(69)	1(62)	1(63)	2(63) (64)	1(68)
Occlusor of the Spiracle.	1(70)	1(63)	1(64)	1(65)	1(69)
Dorsal Dilator of the Spiracle.	—	1(64)	1(65)	—	—
II Segment					
Dorsal Muscles.	3(71) (72) (73)	—	1(66)	2(66) (67)	1(70)
Dorsal Transverse Muscles.	3(74) (75) (76)	—	—	1(68)	1(71)
Ventral Muscles.	1(77)	1(65)	1(67)	1(69)	1(72)
Ventral Transverse Muscles.	1(78	—	—	—	—
Tergo-Sternal Muscles.	2(79) (80)	1(66)	1(68)	1(70)	1(73)
Occlusor of the Spiracle.	1(81)	1(67)	1(69)	1(71)	1(74)
Dorsal Dilator of the Spiracle.	—	1(68)	1(70)	—	—
III–IV Segments					
Dorsal Muscles.	3(71) (72) (73)	—	1(71)	2(72) (73)	1(75)
Dorsal Transverse Muscles.	2(82) (76)	—	1(72)	1(74)	1(76)
Ventral Muscles.	1(77)	1(69)	1(73)	1(75)	1(77)
Ventral Transverse Muscles.	1(83)	—	—	—	—
Tergo-Sternal Muscles.	1(80)	1(70)	1(74)	1(76)	1(78)
Occlusor of the Spiracle.	1(81)	1(71)	1(75)	1(77)	1(79)
Dorsal Dilator of the Spiracle.	—	1(72)	1(76)	—	—

the *Ctenacroscelis* (Fig. 44, 62) arising on the mesothoracic epimeron, in the *Pecticus* (Fig. 45, 59) on the subspiraculare, in the *Lathyrophthalmus* (Fig. 46, 59), *Calobata* (Fig. 47, 59) and *Orthellia* (Fig. 48, 62) on the lateral intersegmental ridge, all these each take the insertion into the ventral side of the spiracle.

d. Abdominal Musculature

The muscles of the anterior abdominal segments are shown in Figures 44-48 and Table XVIII.

III. COMPARISON OF THE THORACIC MUSCLES IN PTERYGOTE INSECTS

Comparing the thoracic muscles of pterygote insects, there are found various types in the arrangements, and the insects are divisible into several types by the difference of the musculatures.

a. Prothoracic Muscles

1. Dorsal Muscles

The prothoracic dorsal muscles in pterygote insects may be classified into three kinds:

a) Median dorsal muscles arising on the dorsal posterior end of the head, the cervical dorsal region, or the protergal plate, and attached on the mesotergum near the dorsal median line. These are often subdivided into two kinds, internals and externals.

b) Lateral dorsal muscles arising on the dorsal posterior end of the head, the cervical dorsal region, or the protergal plate, and attached on the lateral portion of the anterior end of the mesotergum. These are often subdivided into two kinds, internals and externals.

c) Anterior dorsal muscles arising on the dorso-lateral portion of the posterior end of the head, or the dorso-lateral cervical region near the head, and attached on the median portion of the cervical or the protergal region.

Pterygote insects will be divisible into several types according to the arrangement of dorsal muscles:

I. Insects provided with the median, the lateral and the anterior dorsal muscles.

1) Insects provided with the median internal, the median external, the lateral internal, the lateral external, and the anterior dorsal muscles: Blattidae, Mantidae and Acridiidae in Orthoptera, *Cicada* (BERLESE, 1909) of Cicadidae in Hemiptera, Syntomidae and Sphingidae (BERLESE, 1909) in Lepidoptera. The anterior dorsal muscles in Mantidae, *Locusta* of Acridiidae, *Cicada* (BERLESE, 1909) and Syntomidae are two-paired, those in Sphingidae (BERLESE, 1909) are four-paired.

2) Insects provided with the median internal dorsals, the median external dorsals, the lateral dorsals undivided into internals and externals, and the anterior dorsals: *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Embioptera, Cicadidae in Hemiptera, Geometridae in Lepidoptera, Cicindelidae, Carabidae, Staphylinidae, Coccinellidae, Chrysomelidae and Dytiscidae (BAUER, 1910) in Coleoptera. The anterior dorsal muscles in *Dissosteira* and Cicindelidae are two-paired.

3) Insects provided with the median dorsals undivided into internals and externals, the lateral internal dorsals, the lateral external dorsals, and the anterior dorsals: *Megacrania* (MAKI, 1935) of Phasmidae, Tettigonidae and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Plecoptera, Isoptera, Neuroptera, Tortricidae and Papilionidae in Lepidoptera. The lateral internal dorsal muscles in *Megacrania* and Neuroptera are two-paired; the lateral external dorsal ones in *Megacrania* and Papilionidae are two-paired, those in Neuroptera are three-paired; the anterior dorsal muscles of *Megacrania*, Tettigonidae, Neuroptera and Papilionidae are two-paired.

4) Insects provided with the median and the lateral dorsals undivided into internals and externals, and the anterior dorsals: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Brachytrupes* and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Dermaptera, Ephemeroptera,

Crocothemis of Libellulidae and Agrionidae in Odonata, Thysanoptera, Pentatomidae and *Macrohomotoma* of Psyllidae in Hemiptera, Plutellidae in Lepidoptera, and Scarabaeidae in Coleoptera. The anterior dorsal muscles are one-paired, exceptionally two-paired (*G. domesticus; Eurostus* of Pentatomidae) or three-paired (*Dixippus; Nezara* of Pentatomidae, MALOUF, 1933).

II. Insects provided with the median dorsals and the lateral dorsals: *Hexagenia* (KNOX, 1935) in Ephemeroptera and Tenebrionidae in Coleoptera have the median dorsal muscles divided into internals and externals, and the lateral dorsal muscles undivided into internals and externals; Jassidae in Hemiptera, Hydrophilidae (BERLESE, 1909) in Coleoptera, and Stratiomyidae, *Lathyrophthalmus* of Syrphidae, Micropezidae and Muscidae in Diptera have the median and the lateral dorsal muscles undivided into internals and externals.

III. Insects provided with the median dorsals and the anterior dorsals.

1) Insects provided with the median dorsals undivided into internals and externals, and the anterior dorsals: Psocoptera, Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935) and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera.

2) Insects provided with the median internal dorsals, the median external dorsals, and the anterior dorsals: Corixidae in Hemiptera.

IV. Insects provided with the lateral dorsals and the anterior dorsals: Trichoptera.

V. Insects provided with only the lateral dorsal muscles: Vespidae in Hymenoptera.

VI. Insects provided with only the median dorsal muscles: *Diplax* (BERLESE, 1909) of Libellulidae in Odonata, Mecoptera, Tipulidae and *Volucella* (BERLESE, 1909) of Syrphidae in Diptera.

VII. Insects lacking the prothoracic dorsal muscles: Tenthredinidae and Ichneumonidae in Hymenoptera.

2. Ventral Muscles

The prothoracic ventral muscles in Pterygota may be classified into four kinds as follows:

a) Long longitudinal or internal ventral muscles arising on the posterior ventral portion of the head and attached on the profurcal arms.

b) Short longitudinal or external ventral muscles stretched between the cervical region or the main sternal plate (Papilionidae and Diptera) and the profurcal arms.

c) Cruciate ventral muscles arising on the ventro-lateral cervical sclerite and attached on the furcal arm of the opposite side. These muscles may be modified ones of the preceding.

d) Anterior ventral muscles arising on the posterior ventral portion of the head and attached on the cervical region.

Pterygote insects will be divisible into six types according to the arrangement of ventral muscles:

I. Insects provided with the long longitudinal ventrals, the short longitudinal or external ventrals, the cruciate ventrals, and the anterior ventrals: Acridiidae in Orthoptera.

II. Insects provided with the long longitudinal ventrals, the short longitudinal or external ventrals, and the anterior ventrals: *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, and Dermaptera.

III. Insects provided with the long longitudinal ventrals and the anterior ventrals: Tettigonidae in Orthoptera, and Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935).

IV. Insects provided with the long longitudinal ventrals and the short longitudinal or external ventrals: Blattidae, Phasmidae and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Plecoptera, Embioptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, Cicadidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, many Hymenoptera, and Diptera.

V. Insects provided with only the long longitudinal ventral muscles: Mantidae and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Isoptera, Psocoptera, Ephemeroptera, *Crocothemis* of Libellulidae and Agrionidae in Odonata, Pentatomidae, Corixidae, Jassidae

and Psyllidae in Hemiptera, Cicindelidae, Carabidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera.

VI. Insects provided with only the short longitudinal or external ventral muscles: *Diplax* (BERLESE, 1909) of Libellulidae in Odonata, and Thysanoptera.

3. Ventral Transverse Muscles

The prothoracic ventral transverse muscles correspond to the posterior ventral transverse muscles of the pterothorax in their positions. These may be divided into two kinds:

a) Muscles arising on the profurcal arms, and attached to the spina between the pro- and mesosternum. In Embioptera there are found muscles similar to the former, but attached to the sternal wall rather than to the spina; these may be modified muscles of the preceding. Insects provided with the ventral transverse muscles of this type: Blattidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Isoptera, Embioptera, Psocoptera, *Crocothemis* of Libellulidae and Agrionidae in Odonata, Neuroptera, Trichoptera, Lepidoptera, and Tenthredinidae in Hymenoptera.

b) Muscles stretched directly between the furcal arms of both sides. Insects provided with the ventral transverse muscles of this type: Mecoptera, and Tipulidae in Diptera.

The following insects lack the ventral transverse muscles: Mantidae, Phasmidae, and *Atractomorpha* of Acridiidae in Orthoptera, Plecoptera, Ephemeroptera, Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935), Thysanoptera, Hemiptera, Coleoptera, Ichneumonidae and Vespidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

4. Tergo-Sternal Muscles

The prothoracic tergo-sternal muscles are divisible into four kinds: anterior intersegmental tergo-sternals, anterior internal tergo-sternals, anterior external tergo-sternals, and posterior tergo-sternals.

A. The anterior intersegmental tergo-sternals are found on most

of pterygote insects. The dorsal attached positions of these muscles are usually situated on the posterior end of the head, but the ventral attached positions vary in different insects. These muscles may be divided into three types by the ventral attached positions.

a) Muscles attached on the ventro-lateral cervical sclerites.

b) Muscles attached on the main prosternal plate.

c) Muscles attached on the profurcal arms.

Pterygote insects may be divided into five types by these muscles:

I. Insects provided with the tergo-sternal muscles of a-type: Blattidae, Mantidae, Phasmidae, Acridiidae, Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeroptera, Odonata, Thysanoptera, Cicadidae in Hemiptera, Hydrophilidae (BERLESE, 1909) in Coleoptera, *Tenthredo* (WEBER, 1927) and *Vespa crabro* (WEBER, 1926) in Hymenoptera, and Diptera.

II. Insects provided with the tergo-sternal muscles of a- and b-type: *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Staphylinidae, Coccinellidae and Scarabaeidae in Coleoptera, and Ichneumonidae in Hymenoptera.

III. Insects provided with the tergo-sternal muscles of a- and c-type: Neuroptera, Mecoptera, Trichoptera, Lepidoptera, *Eutomostethus* and *Schizocerus* (WEBER, 1927) of Tenthredinidae in Hymenoptera.

IV. Insects provided with the tergo-sternal muscles of b- and c-type: Vespidae in Hymenoptera.

V. Insects provided with the tergo-sternal muscles of b-type: Pentatomidae, Corixidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Cicindelidae, Carabidae, Dytiscidae (BAUER, 1910) (?) and Chrysomelidae in Coleoptera.

B. The anterior internal tergo-sternal muscles are usually situated on the inside of the anterior intersegmental tergo-sternal muscles and divisible into four kinds as follows:

a) Muscles arising on the protergal plate or the upper cervical region and inserted into the sclerites of the lower cervical region.

b) Muscles arising on the protergal plate or the upper cervical region and inserted into the lower portion of the head.

c) Muscles arising on the mesotergum and attached on the sclerites of the lower cervical region.

d) Muscles originated on the anterior end of the mesotergum and inserted into the lower portion of the head.

Pterygote insects will be divisible into six types by the anterior internal tergo-sternal muscles:

I. Insects provided with the anterior internal tergo-sternal muscles of a-type: Blattidae, Mantidae, Phasmidae, *Locusta* and *Atractomorpha* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeroptera, Odonata, Thysanoptera, Neuroptera, Tortricidae, Papilionidae, Geometridae and Syntomidae in Lepidoptera, Staphylinidae, Coccinellidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and Vespidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

II. Insects provided with the anterior internal tergo-sternal muscles of b-type: Corixidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Sphingidae (BERLESE, 1909) in Lepidoptera, and Cicindelidae in Coleoptera.

III. Insects provided with the anterior internal tergo-sternal muscles of a- and b-type: *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, and Cicadidae in Hemiptera.

IV. Insects provided with the anterior internal tergo-sternal muscles of a- and c-type: Mecoptera, Trichoptera, Plutellidae in Lepidoptera, and Scarabaeidae in Coleoptera.

V. Insects provided with the anterior internal tergo-sternal muscles of b- and d-type: Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Carabidae, Tenebrionidae, Chrysomelidae and Dytiscidae (BAUER, 1910) in Coleoptera.

VI. Insects lacking the anterior internal tergo-sternal muscles: Pentatomidae in Hemiptera, and Tipulidae in Diptera.

C. The anterior external tergo-sternal muscles are attached dor-

sally on the protergum or the dorsal cervical region and ventrally on the ventro-lateral cervical sclerites, situated on the outside of the anterior intersegmental tergo-sternal muscles. These are found on Phasmidae and *Brachytrupes* and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Dermaptera, Embioptera, Neuroptera, Stratiomyidae, *Lathyrophthalmus* of Syrphidae, Micropezidae and Muscidae in Diptera.

D. The posterior tergo-sternal muscles connect the anterior end of the mesotergum mainly with the profurcal arms or rarely the prosternum. These are found in one pair on many pterygote insects, in two pairs on Mantidae and Phasmidae in Orthoptera, Isoptera, Embioptera, and Psyllidae in Hemiptera, but lack in Odonata, Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

5. Tergo-Pleural Muscles

The prothoracic tergo-pleural muscles may be classified into two kinds, anterior tergo-pleural muscles arising on the posterior end of the upper region of the head and attached on the pleuron, and ordinary tergo-pleural muscles stretched between the tergum and the pleuron.

Pterygote insects will be divisible into four types by these tergo-pleural muscles:

I. Insects provided with only the anterior tergo-pleural muscles: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, Acridiidae and *Brachytrupes* of Gryllidae in Orthoptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, Jassidae in Hemiptera, Hydrophilidae (BERLESE, 1909) in Coleoptera, and *Schizocerus* (WEBER, 1927) of Tenthredinidae in Hymenoptera.

II. Insects provided with only the ordinary tergo-pleural muscles: Blattidae, Mantidae and *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Dermaptera, Plecoptera, Embioptera, Agrionidae, Coenagrionidae (MALOUF, 1935) and Aeschnidae (MALOUF, 1935) in Odonata, *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, many Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae,

Chrysomelidae and Scarabaeidae in Coleoptera, Ichneumonidae in Hymenoptera, and Tipulidae in Diptera.

III. Insects provided with both the anterior and the ordinary tergo-pleural muscles: *Gryllus domesticus* (VOSS, 1905) and *G. assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Isoptera, Psocoptera, Ecdyonuridae in Ephemeroptera, *Crocothemis* of Libellulidae in Odonata, *Huechys* of Cicadidae in Hemiptera, Trichoptera, *Eutomostethus* of Tenthredinidae and Vespidae in Hymenoptera.

IV. Insects lacking the tergo-pleural muscles: Tettigonidae in Orthoptera, Thysanoptera, Pentatomidae, Corixidae, *Cicada* (BERLESE, 1909) of Cicadidae, and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Plutellidae in Lepidoptera, Cicindelidae and Dytiscidae (BAUER, 1910) in Coleoptera, *Tenthredo* (WEBER, 1927) in Hymenoptera, and many Diptera.

6. Sterno-Pleural Muscles

The prothoracic sterno-pleural muscles may be divided into two kinds, anterior sterno-pleural muscles stretched between the ventro-lateral cervical sclerites and the pleura, and furco-entopleural muscles between the pleural arms and the furcal arms.

In pterygote insects there are found four types as follows:

I. Insects provided with only the anterior sterno-pleural muscles: Dermaptera.

II. Insects provided with only the furco-entopleural muscles: Blattidae, Mantidae, *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Locusta* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Plecoptera, Psocoptera, Libellulidae and Agrionidae in Odonata, Thysanoptera, *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, *Schizocerus* and *Tenthredo* of Tenthredinidae (WEBER, 1927) and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera.

III. Insects lacking the sterno-pleural muscles, but having the traces (chitinous sterno-pleural bridges) of the stretching of the furco-entopleural muscles: *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Isoptera, Corixidae, Cicadidae and Jassidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera,

Eutomostethus of Tenthredinidae, Ichneumonidae and *Vespa ducalis* of Vespidae in Hymenoptera, and Diptera.

IV. Insects having neither sterno-pleural muscle nor sterno-pleural chitinous bridge: *Megacrania* (MAKI, 1935) of Orthoptera, Embioptera, Ephemeroptera, Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935), Pentatomidae and *Macrohomotoma* of Psyllidae in Hemiptera, and Coleoptera.

7. Coxal Muscles

(*a*) *Tergal Promotors of thc Coxae*

The tergal promotors are found in one pair on *Megacrania* (MAKI, 1935) of Phasmidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Isoptera, Psocoptera, Ephemeroptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935), Agrionidae and *Diplax* (BERLESE, 1909) of Libellulidae in Odonata, Pentatomidae, *Cicada* (BERLESE, 1909) of Cicadidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Staphylinidae, Coccinellidae, Tenebrionidae and Chrysomelidae in Coleoptera, in two pairs on *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Plecoptera, Embioptera, *Crocothemis* of Libellulidae in Odonata, *Huechys* of Cicadidae in Hemiptera, Neuroptera, Cicindelidae and Carabidae in Coleoptera, in three pairs on Blattidae in Orthoptera, and Dytiscidae (BAUER, 1910) in Coleoptera, and in four pairs on Mantidae in Orthoptera and Thysanoptera.

The tergal promotors may be divided into two kinds by their attached positions:

a) Muscles arising on the tergal region and inserted into the trochantin.

b) Muscles arising on the tergal region and attached on the anterior basal rim of the coxa.

Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Pentatomidae, Cicadidae and Jassidae in Hemiptera, Cicindelidae and Carabidae in Coleoptera have the tergal promotors of a-type.

Psocoptera, Ephemeroptera, Odonata, *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, Staphilinidae, Tenebrionidae, Coccinellidae and Chrysomelidae in Coleoptera have the tergal promotors of b-type.

In Thysanoptera there are the tergal promotors of both a- and b-type.

Corixidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Mecoptera, Trichoptera, Lepidoptera, Scarabaeidae in Coleoptera, Hymenoptera and Diptera lack the muscles homologous to the tergal promotors in other insects.

(*b*) *Pleural Promotors of the Coxae*

Many pterygote insects lack the pleural promotors, but *Megacrania* (MAKI, 1935) of Phasmidae, *Atractomorpha* of Acridiidae, *Gryllus* of Gryllidae in Orthoptera, Carabidae and Staphilinidae in Coleoptera have a pleural promotor arising on the episternal region and inserted into the trochantin or the anterior basal rim of the coxa (Coleoptera) on each side.

(*c*) *Sternal Promotors of the Coxae*

The sternal promotors are divisible into two kinds by their arising positions: Anterior sternal promotors arising on the ventro-lateral cervical sclerites or the posterior tentorial arms of the head (Lepidoptera), and attached on the anterior basal rims of coxae, and ordinary sternal promotors arising on the main sternal plate and inserted into the anterior coxal basal rims. The muscles of each kind are one-paired in many cases, but the ordinary sternal promotors in some insects, such as *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Plecoptera, Tortricidae and Papilionidae in Lepidoptera, and Trichoptera, are two-paired.

Pterygote insects may by divided into four types by these muscles:.

I. Insects provided with only the anterior sternal promotors: Psocoptera.

II. Insects provided with only the ordinary sternal promotors: Blattidae, *Megacrania* (MAKI, 1935) of Phasmidae, *Locusta* and *Atractomorpha* of Acridiidae in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Thysanoptera, *Nezara* (MALOUF, 1933) of Pentatomidae, Corixidae and Cicadidae in Hemiptera, Trichoptera, *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera, and Tipulidae in Diptera.

III. Insects provided with both the anterior sternal promotors and the ordinary sternal promotors: Mantidae, Tettigonidae and Gryllidae in Orthoptera, *Crocothemis* of Libellulidae and Agrionidae in Odonata, *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, Mecoptera, Lepidoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and *Vespa ducalis* of Vespidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

IV. Insects lacking the sternal promotors: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Ephemeroptera, Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935; their larvae have the anterior sternal promotors), *Eurostus* of Pentatomidae, Jassidae, *Psylla* (WEBER, 1929) of Psyllidae and *Cicada* (BERLESE, 1909) of Cicadidae in Hemiptera, and Coleoptera.

(*d*) *Tergal Remotors of the Coxae*

The number of the tergal remotors varies in different insects as follows:

I. Insects provided with a tergal remotor on each coxa: Psocoptera, Libellulidae, Aeschnidae (MALOUF, 1935) and Coenagrionidae (MALOUF, 1935) in Odonata, Thysanoptera, Pentatomidae, *Cicada* (BERLESE, 1909) of Cicadidae, and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Neuroptera, Trichoptera, Papilionidae, Geometridae and Syntomidae in Lepidoptera, Coccinellidae, Chrysomelidae and Dytiscidae (BAUER, 1910) in Coleoptera, and *Eutomostethus* of Tenthredinidae, Ichneumonidae and Vespidae in Hymenoptera.

II. Insects provided witd two tergal remotors on each coxa: Dermaptera, Empioptera, Agrionidae in Odonata, Corixidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Mecoptera, Cicindelidae, Staphylinidae, Tenebrionidae and Scarabaeidae in Coleoptera.

III. Insects provided with three tergal remotors on each coxa: Blattidae, Phasmidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Plecoptera, Isoptera, Ephemeroptera, and Carabidae in Coleoptera.

IV. Insects provided with four tergal remotors on each coxa:

Gryllus assimilis (DU PORTE, 1920) of Gryllidae in Orthoptera, and *Huechys* of Cicadidae in Hemiptera.

V. Insects provided with six tergal remotors on each coxa: Mantidae in Orthoptera.

VI. Insects lacking the tergal remotors on the coxa: Plutellidae and Tortricidae in Lepidoptera, and Diptera.

(*e*) *Pleural Remotors of the Coxae*

In Holometabola, the pleural remotors are found in one pair on Neuroptera, Trichoptera, Plutellidae, Tortricidae, Papilionidae, Syntomidae and Sphingidae (BERLESE, 1909) in Lepidoptera, Scarabaeidae in Coleoptera, *Vespa ducalis* of Vespidae in Hymenoptera, Micropezidae and Muscidae in Diptera, and in two pairs on Geometridae in Lepidoptera. In Hemimetabola there are not found the pleural remotors in general, except the case in Gryllotalpidae (CARPENTIER, 1923, 36).

(*f*) *Sternal Remotors of the Coxae*

The sternal remotors are divisible into two kinds by their attached portions: Posterior spinal remotors arising on the median apophysis between the pro- and mesosternum and attached on the posterior bases of the coxae, and ordinary sternal remotors arising on the sternal wall or the furcal arms and inserted into the posterior basal rims of the coxae.

In pterygote insects there are found four types as follows:

I. Insects provided with only the posterior spinal remotors: Blattidae, *Locusta* and *Atractomorpha* of Acridiidae in Orthoptera, Thysanoptera, Tortricidae and Syntomidae in Lepidoptera. Blattidae and *Locusta* have two pairs of the posterior spinal remotors, and the others have one pair of the posterior spinal remotors.

II. Insects provided with only the ordinary sternal remotors: Mantidae, Phasmidae and Tettigonidae in Orthoptera, Plecoptera, Embioptera, Psocoptera, Ephemeroptera, Odonata, *Nezara* (MALOUF, 1933) of Pentatomidae, Corixidae, Jassidae and Psyllidae in Hemiptera, Neuroptera, Mecoptera, Papilionidae in Lepidoptera, Cicindelidae, Carabidae, Coccinellidae, Chrysomelidae and Dytiscidae (BAUER, 1910) in Coleoptera, Vespidae in Hymenoptera, and Diptera. The ordinary

sternal remotors in *Macrohomotoma* of Psyllidae, Mecoptera and Micropezidae are two-paired, and those in the others are one-paired.

III. Insects provided with one pair of the posterior spinal remotors and one pair of the ordinary sternal remotors: *Dissosteira* (SNODGRASS, 1929) of Acridiidae and Gryllidae in Orthoptera, Isoptera, Trichoptera, Plutellidae and Geometridae in Lepidoptera, *Eutomostethus* of Tenthredinidae and Ichneumonidae in Hymenoptera.

IV. Insects lacking the sternal remotors: Dermaptera, *Eurostus* of Pentatomidae and *Huechys* of Cicadidae in Hemiptera, Sphingidae (BERLESE, 1909) in Lepidoptera, Staphylinidae, Tenebrionidae and Scarabaeidae in Coleoptera.

(*g*) *Pleural Adductors of the Coxae*

The pleural adductors are not found on many pterygote insects, but found in one pair on Phasmidae and Gryllotalpidae (CARPENTIER, 1923, 36) in Orthoptera and Dermaptera.

(*h*) *Sternal Adductors of the Coxae*

The sternal adductors are found in one pair on Orthoptera, Plecoptera and Embioptera, but are lacking in many higher insects.

(*i*) *Tergal Abductors of the Coxae*

The tergal abductors are found in one pair on Mantidae and Phasmidae in Orthoptera, Plecoptera, Isoptera, Embioptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, *Eurostus* of Pentatomidae, Corixidae, Cicadidae and Jassidae in Hemiptera, in two pairs on Blattidae in Orthoptera, Ecdyonuridae in Ephemeroptera, *Macrohomotoma* of Psyllidae in Hemiptera, and in three pairs on Thysanoptera, but lacking in Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Psocoptera, Odonata, *Nezara* (MALOUF, 1933) of Pentatomidae in Hemiptera, and on holometabolous insects.

(*j*) *Pleural Abductors of the Coxae*

The pleural abductors are found in one pair on Mantidae, Phasmidae, *Gryllus* (VOSS, 1905; DU PORTE, 1920) in Orthoptera, Dermaptera, Isoptera, Embioptera, Psocoptera, Ephemeroptera, Thysanoptera, *Eurostus* of Pentatomidae and Psyllidae in Hemiptera, Neuroptera, Mecoptera, Tortricidae, Papilionidae, Geometridae and Sphingidae (BER-

LESE, 1909) in Lepidoptera, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, Tenthredinidae and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera, Syrphidae, Micropezidae and Muscidae in Diptera, and in two pairs on Blattidae, Acridiidae, Tettigonidae, and *Brachytrupes* of Gryllidae in Orthoptera, *Huechys* of Cicadidae and Jassidae in Hemiptera, Trichoptera, Plutellidae and Syntomidae in Lepidoptera, Ichneumonidae and Vespidae in Hymenoptera, Tipulidae and Stratiomyidae in Diptera.

Plecoptera, Odonata, *Nezara* (MALOUF, 1933) of Pentatomidae, and Corixidae in Hemiptera, Cicindelidae, Carabidae, Staphylinidae, Coccinellidae and Dytiscidae (BAUER, 1910) in Coleoptera lack the pleural abductors.

8. Trochanteral Muscles Arising on the Thorax

(a) Tergal Depressors of the Trochanters

The tergal depressors are found in a pair on Blattidae, *Dixippus* (JEZIORSKI, 1918) of Phasmidae, Acridiidae, Tettigonidae, *Brachytrupes* of Gryllidae in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Agrionidae and *Diplax* (BERLESE, 1909) of Libellulidae in Odonata, Pentatomidae, Cicadidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Cicindelidae in Coleoptera, Stratiomyidae, Syrphidae and Muscidae in Diptera, in two pairs on *Gryllus assimilis* (DU PORTE, 1920) in Orthoptera, and in three pairs on Mantidae and *Gryllus domesticus* (VOSS, 1905) in Orthoptera. *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Ephemeroptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935) and *Crocothemis* of Libellulidae in Odonata, Thysanoptera, Corixidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae and Dytiscidae (BAUER, 1910) in Coleoptera, Hymenoptera, and Tipulidae and Micropezidae in Diptera lack the tergal depressors.

(b) Pleural Depressors of the Trochanters

The pleural depressors are one-paired in Blattidae, Mantidae, Phasmidae, *Atractomorpha* of Acridiidae and *Gryllus domesticus* (VOSS, 1905)

of Gryllidae in Orthoptera, Dermaptera, Isoptera, Embioptera, Ephemeroptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935), Agrionidae and *Crocothemis* of Libellulidae in Odonata, Thysanoptera, Pentatomidae, Corixidae, *Huechys* of Cicadidae and Jassidae in Hemiptera, Trichoptera, Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1910) in Coleoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and *Vespa ducalis* in Hymenoptera, Stratiomyidae and Micropezidae in Diptera, two-paired in *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae and Tettigonidae in Orthoptera, *Macrohomotoma* of Psyllidae in Hemiptera, Mecoptera, Tipulidae in Diptera, three-paired in the *Brachytrupes* of Gryllidae in Orthoptera and Tenebrionidae in Coleoptera, and four-paired in *Gryllus assimilis* (DU PORTE, 1920) in Orthoptera. Plecoptera, Psocoptera, *Psylla* (WEBER, 1929) in Hemiptera, Neuroptere (MAKI, 1936), Cicindelidae in Coleoptera, *Tenthredo* and *Schizocerus* of Tenthredinidae (WEBER, 1927) and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera, Syrphidae and Muscidae in Diptera lack the pleural depressors.

(*c*) *Sternal Depressors of the Trochanters*

The sternal depressors are usually one-paired if present. *Atractomorpha* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Plecoptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935), Agrionidae and *Crocothemis* of Libellulidae in Odonata, Thysanoptera, *Eurostus* of Pentatomidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, *Schizocerus* and *Tenthredo* of Tenthredinidae (WEBER, 1927) and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera, Tipulidae, Stratiomyidae, Syrphidae and Muscidae in Diptera have the sternal depressors, but Blattidae, Mantidae, Phasmidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptere, Isoptera, Embioptera, Psocoptera, Ephemeroptera, *Nezara* (MALOUF, 1933) of Pentatomidae, Corixidae, *Huechys* of Cicadidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Trichoptera, Lepidoptera, Coleoptera, *Eutomostethus* of Tenthredinidae,

Ichneumonidae and *Vespa ducalis* of Vespidae in Hymenoptera, and Micropezidae in Diptera lack the sternal depressors.

b. Mesothoracic Muscles

1. Dorsal Muscles

The mesothoracic dorsal muscles are divisible into two kinds by their attached positions, median dorsal muscles and lateral dorsal muscles.

a) The median dorsal muscles may be divided into three kinds, median internal dorsals, median external dorsals, and median dorsals undivided into internals and externals.

b) The lateral dorsal muscles may be divided into three kinds, lateral internal dorsals, lateral external dorsals, and lateral dorsals undivided into internals and externals.

Pterygote insects may be classified into several types by the dorsal muscles:

I. Insects provided with only the median dorsal muscles.

i. Insects provided with the median internal and the median external dorsal muscles: *Atractomorpha* of Acridiidae in Orthoptera, Dytscidae (BAUER, 1910) in Coleoptera, Ichneumonidae and Vespidae in Hymenoptera.

ii. Insects provided with median dorsal muscles undivided into internals and externals: Thysanoptera, Cicindelidae, Carabidae and Scarabaeidae in Coleoptera.

II. Insects provided with only the lateral dorsal muscles undivided into internals and externals: Odonata.

III. Insects provided with both the median and the lateral dorsal muscles:

i. Insects provided with the median internal, the median external, the lateral internal, and the lateral external dorsal muscles: Blattidae, Phasmidae and *Locusta* of Acridiidae in Orthoptera, and Neuroptera (MAKI, 1936).

ii. Insects provided with the median dorsal muscles undivided into internals and externals, the lateral internal and the lateral external dorsal muscles: Mantidae in Orthoptera, and Isoptera.

iii. Insects provided with the median and the lateral dorsal muscles undivided into internals and externals: *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Plecoptera, Psocoptera, Ephemeroptera, Hemiptera, Mecoptera, Plutellidae, Tortricidae and Syntomidae in Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae and Chrysomelidae in Coleoptera, Tipulidae, Stratiomyidae, Syrphidae and Micropezidae in Diptera.

iv. Insects provided with the median internal and the median external dorsal muscles, and the lateral dorsal muscles undivided into internals and externals: Embioptera, Trichoptera, *Papilio thaiwanus* of Papilionidae, Sphingidae (BERLESE, 1909) and Geometridae in Lepidoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera, Muscidae in Diptera.

2. Dorsal Transverse Muscles

The mesothoracic dorsal transverse muscles are found on Blattidae in Orthoptera, but lacking in most of pterygote insects. The former type may be more primitive than the latter, since many apterygote insects also have dorsal transverse muscles on their mesothorax as already mentioned.

3. Ventral Muscles

On the mesothorax are found eight kinds of ventral muscles:

a) Longitudinal ventral muscles attached anteriorly on the profurcal arms or rarely on the posterior end of the prosternum, and posteriorly on the mesofurcal arms.

b) Unpaired longitudinal median ventral muscles attached anteriorly on the spina between the pro- and mesosternum and posteriorly on the spina between the meso- and metasternum.

c) Oblique mesospino-mesofurcal ventral muscles arising on the spina between the pro- and mesosternum and attached on the mesofurcal arms.

d) Oblique profurco-metaspinal ventral muscles attached anteriorly on the profurcal arms and posteriorly on the spina between the meso- and metasternum.

e) Oblique mesospino-metasternal ventral muscles attached an-

teriorly on the spina between the pro- and mesosternum and posteriorly on the antero-lateral portions of the metasternum.

f) Oblique slender ventral muscles arising on the antero-lateral corners of the mesosternum and attached on the mesofurcal arms.

g) Anterior very short ventral muscles arising on the posterior end of the prosternum and attached to the mesopresternum.

h) Posterior ventral muscles arising on the mesofurcal arms and attached on the antero-lateral corners of the metasternal region. In Odonata and Lepidoptera there is a tendinous connection between the mesofurcal arm and the lateral portion of the intersegmental region at the anterior end of the metasternum. It may be a trace of stretching of the ventral muscle of this type.

Pterygote insects will be divisible into eleven types by the ventral muscles:

I. Insects provided with the ventral muscles of a-type: Ephemeroptera, Odonata, Pentatomidae, Corixidae, *Huechys* of Cicadidae, Jassidae and Psyllidae in Hemiptera, *Papilio* (WEBER, 1928) and *Sphinx* (BERLESE, 1909) in Lepidoptera, Cicindelidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, Hymenoptera, and *Volucella* (BERLESE, 1909) of Syrphidae in Diptera.

II. Insects provided with the ventral muscles of a- and b-type: Blattidae in Orthoptera.

III. Insects provided with the ventral muscles of a-, b- and c-type: Tettigonidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera.

IV. Insects provided with the ventral muscles of a-, b-, c- and d-type: Gryllidae in Orthoptera.

V. Insects provided with the ventral muscles of a-, b-, c- and h-type: Mantidae in Orthoptera.

VI. Insects provided with the ventral muscles of a- and c- type: *Atractomorpha* of Acridiidae in Orthoptera, Plecoptera, Psocoptera, Thysanoptera, *Cicada* (BERLESE, 1909) of Cicadidae in Hemiptera, Mecoptera, Trichoptera, many Lepidoptera, and Carabidae in Coleoptera.

VII. Insects provided with the ventral muscles of a-, b-, and d-type: Isoptera and Embioptera.

VIII. Insects provided with the ventral muscles of a-, b- and e-type: Dermaptera.

IX. Insects provided with the ventral muscles of a- and f-type: Neuroptera.

X. Insects provided with the ventral muscles of g-type: Phasmidae in Orthoptera.

XI. Insects lacking the ventral muscles: Diptera.

4) **Ventral Transverse Muscles**

On the mesothorax are found two kinds of ventral transverse muscles:

a) Anterior ventral transverse muscles divisible into two kinds:

1. Muscles arising on the ventro-lateral portion of the anterior end of the sternal region and attached on the median apophysis at the anterior end of the mesosternum.

2. Muscles stretched directly between both sides of the anterior end of the sternal region without the median attachment.

b) Posterior ventral transverse muscles divisible into two kinds:

1. Muscles stretched originated on the furcal arm and inserted into the median apophysis at the posterior end of the sternum.

2. Muscles stretched directly between the furcal arms of both sides.

Pterygote insects will be divisible into six types by the ventral transverse muscles:

I. Insects provided with the ventral transverse muscles of a1-type: Mantidae in Orthoptera, Plecoptera, Isoptera, *Crocothemis* of Libellulidae and Agrionidae in Odonata, and Trichoptera.

II. Insects provided with the ventral transverse muscles of b1-type: Mecoptera.

III. Insects provided with the ventral transverse muscles of b2-type: *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, and Ephemeroptera.

IV. Insects provided with the ventral transverse muscles of a1-

and b1-type: Blattidae and Tettigonidae in Orthoptera, Dermaptera and Neuroptera.

V. Insects provided with the ventral transverse muscles of a2- and b2-type: Tipulidas in Diptera.

VI. Insects lacking the ventral transverse muscles: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, Acridiidae and Gryllidae in Orthoptera, Embioptera, Psocoptera, Thysanoptera, Hemiptera, Lepidoptera, Coleoptera, Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

5. Tergo-Sternal Muscles

The tergo-sternal muscles may be classified into four kinds:

a) Anterior tergo-sternal muscles arising on the antero-lateral regions of the mesotergum or the postero-lateral portions of the protergum (*Borolinus* in Coleoptera) and attached on the antero-lateral regions of the mesosternum.

b) Posterior tergo-sternal muscles attached dorsally on the anterior end of the metatergum or the posterior end of the mesotergum and ventrally on the mesofurcal arms, or rarely on the posterior region of the mesosternum (as in the Plecoptera and Mantidae).

c) Sterno-subalar muscles arising on the posterior sternal region or the furcal arms and inserted into the subalar sclerites.

d) Sterno-axillary muscles arising on the furcal arms and inserted into the axillary sclerites.

Pterygote insects will be divisible into five types by the tergo-sternal muscles:

I. Insects provided with only the anterior tergo-sternal muscles: *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae and Tettigonidae in Orthoptera, Odonata, Mecoptera, *Papilio thaiwanus* of Papilionidae and Geometridae in Lepidoptera, and Diptera.

II. Insects provided with only the posterior tergo-sternal muscles: Dermaptera, Psocoptera, and Scarabaeidae and Dytiscidae (BAUER, 1910) in Coleoptera.

III. Insects provided with the anterior and the posterior tergo-sternal muscles: Blattidae, Mantidae, Phasmidae, *Locusta* of Acridii-

dae and Gryllidae in Orthoptera, Plecoptera, Isoptera, Embioptera, Thysanoptera, Hemiptera, Neuroptera, Trichoptera, Plutellidae, Tortricidae, Syntomidae, Sphingidae (BERLESE, 1909) and *Papilio* (WEBER, 1928) of Papilionidae in Lepidoptera, Staphylinidae in Coleoptera, and Hymenoptera. This type is most typical.

IV. Insects provided with the anterior tergo-sternal muscles, the sterno-subalar muscles and the sterno-axillary muscles: Ephemeroptera.

V. Insects lacking the tergo-sternal muscles: Cicindelidae, Carabidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Hydrophilidae (BERLESE, 1909) in Coleoptera.

The number of bundles in each kind of tergo-sternal muscles is one-paired in many pterygote insects, but the anterior tergo-sternal muscles in Plecoptera, Embioptera, Ecdyonuridae in Ephemeroptera, Agrionidae in Odonata, Thysanoptera, Psyllidae in Hemiptera, Neuroptera, and Papilionidae in Lepidoptera are two-paired, the anterior tergo-sternal muscles of Acridiidae in Orthoptera and *Crocothemis* of Libellulidae in Odonata are three-paired, the posterior tergo-sternal muscles of Mantidae in Orthoptera and Tenthredinidae in Hymenoptera are two-paired, and the sterno-subalar muscles in Ephemeroptera are two-paired.

6. Tergo-Pleural Muscles

The tergo-pleural muscles are divisible into three kinds by their attached portions: ordinary tergo-pleural muscles, pleuro-axillary muscles, and pleuro-subalar muscles.

A. The ordinary tergo-pleural muscles may be subdivided into two kinds:

1. Anterior tergo-pleural muscles arising on the anterior lateral portion of the tergum, often near the anterior notal wing process, rarely on the prealar sclerite, and attached on the basalar sclerite or the dorsal margin of the episternum, often on the dorsal portion of the pleural ridge.

2. Posterior tergo-pleural muscles arising on the lateral portion of the tergum between the anterior and the posterior notal wing process, and attached on or near the middle portion of the pleural ridge.

In pterygote insects there are found four types as follows:

I. Insects provided with only the anterior tergo-pleural muscles: *Brachytrupes* of Gryllidae in Orthoptera, Odonata, *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Papilionidae and Sphingidae (BERLESE, 1909) in Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, Ichneumonidae and Vespidae in Hymenoptera, and Diptera.

II. Insects provided with only the posterior tergo-pleural muscles: Jassidae in Hemiptera.

III. Insects provided with the muscles of both the anterior and the posterior tergo-pleural muscles: Blattidae, Mantidae, *Megacrania* (MAKI, 1935) of Phasmidae, *Locusta* of Acridiidae, Tettigonidae, and *Gryllus* (VOSS, 1905; DU PORTE, 1920) or Gryllidae in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera, Thysanoptera, Cicadidae and *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Plutellidae, Tortricidae, Geometridae and Syntomidae in Lepidoptera, Scarabaeidae in Coleoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera.

IV. Insects lacking the ordinary tergo-pleural msucles: *Dixippus* (JEZIORSKI, 1913) of Phasmidae, *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Pentatomidae and Corixidae in Hemiptera, Cicindelidae in Coleoptera.

The number of the ordinary tergo-pleural muscles varies in different insects:

1. The anterior tergo-pleural muscles.

i. Insects provided with a pair of the anterior tergo-pleural muscles: Mantidae, *Megacrania* (MAKI, 1935) of Phasmidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Isoptera, Embioptera, Ephemeroptera, Odonata, *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, Ichneumonidae and Vespidae in Hymenoptera.

ii. Insects provided with two pairs of the anterior tergo-pleural

muscles: Blattidae and *Locusta* of Acridiidae in Orthoptera, Plecoptera, Cicadidae and *Macrohomotoma* of Psyllidae in Hemiptera, Lepidoptera, Tenthredinidae in Hymenoptera.

iii. Insects provided with three pairs of the anterior tergo-pleural muscles: Psocoptera, Thysanoptera, Neuroptera, Mecoptera, Trichoptera, and Diptera.

2. The posterior tergo-pleural muscles.

The posterior tergo-pleural muscles are one-paired in many insects, but two-paired in Blattidae and Mantidae in Orthoptera, Dermaptera, Psocoptera and Neuroptera.

B. The pleuro-axillary muscles are bundles of fibers stretched between the pleura and the sclerites of upper sides of wing bases, found in one pair on Blattidae, Mantidae, *Locusta* of Acridiidae, Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, Libellulidae in Odonata, Thysanoptera, Pentatomidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, and Coleoptera, in two pairs on Phasmidae and *Atractomorpha* of Acridiidae, and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Ecdyonuridae in Ephemeroptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935) and Agrionidae in Odonata, Corixidae, Cicadidae, Jassidae and Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, *Eutomostethus* of Tenthredinidae and Vespidae in Hymenoptera, in three pairs on Ichneumonidae in Hymenoptera, in six pairs on Tipulidae and *Volucella* (BERLESE, 1909) of Syrphidae in Diptera, and in seven pairs on Stratiomyidae, *Lathyrophthalmus* of Syrphidae and Micropezidae in Diptera, and in eight pairs on Muscidae in Diptera.

The wingless insects (as *Dixippus* (JEZIORSKY, 1918) in Orthoptera, *Anisolabis* in Dermaptera) lack the pleuro-axillary muscles.

The arising positions of pleuro-axillary muscles may be divided into two, one on the episterna and the other on the pleural ridges or the epimera along the pleural ridges rarely on the pleural wing processes (as in Odonata). The pleuro-axillary muscles of Blattidae in

Orthoptera, Plecoptera, Embioptera, most of Hemiptera, and Vespidae in Hymenoptera take their origins on the first. Those of Mantidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Isoptera, Psocoptera, Ephemeroptera, Odonata, *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Thysanoptera, Coleoptera, and *Eutomostethus* of Tenthredinidae in Hymenoptera take their origins on the second. *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Neuroptera (MAKI, 1936), Mecoptera, Trichoptera, Lepidoptera, Ichneumonidae in Hymenoptera and Diptera have the pleuro-axillary muscles arising on both the first and second.

The pleuro-axillary muscles are divisible into four kinds by their dorsal attached positions:

a) Muscles attached on the axillary plates.

b) Muscles attached on the first axillary sclerites

c) Muscles attached on the third axillary sclerites.

d) Muscles attached on the fourth axillary sclerites.

i. Insects provided with the pleuro-axillary muscles of a-type: Odonata.

ii. Insects provided with pleuro-axillary muscles of b- and c-type: Ecdyonuridae in Ephemeroptera, and *Macrohomotoma* of Psyllidae (? in *Psylla*, WEBER) in Hemiptera.

iii. Insects provided with the pleuro-axillary muscles of c- and d-type: *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera.

iv. Insects provided with the pleuro-axillary muscles of b-, c-, and d-type: Diptera.

v. Insects provided with only the pleuro-axillary muscles of c-type: Many winged insects.

C. The pleuro-subalar muscles are divisible into two kinds by their pleural arising positions:

1. Muscles arising on the epimera, and attached on the subalar sclerites or the subalar membranes.

2. Muscles arising on the episterna and inserted into the subalar sclerites or the subalar membranes.

Pterygote insects may be classified into three types by the pleuro-subalar muscles:

I. Insects provided with the pleuro-subalar muscles of i-type: *Megacrania* (MAKI, 1935) of Phasmidae and *Locusta* of Acridiidae, and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Plecoptera, Embioptera, *Ephemella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Odonata, *Huechys* of Cicadidae and Psyllidae in Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, Lepidoptera, Tenebrionidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, and *Tenthredo* (WEBER, 1927) in Hymenoptera.

II. Insects provided with pleuro-subalar muscles of 2-type: Vespidae in Hymenoptera.

III. Insects provided with the pleuro-subalar muscles of 1- and 2-type: Coccinellidae and Chrysomelidae in Coleoptera.

IV. Insects lacking the pleuro-subalar muscles: Many winged insects.

Each kind of the pleuro-subalar muscles is one-paired in general, rarely two-paired as in the epimero-subalar muscles of *Psylla* (WEBER, 1929) of Hemiptera, Mecoptera and Chrysomelidae, or three-paired as in the epimero-subalar muscles of Odonata.

7. Sterno-Pleural Muscles

The sterno-pleural muscles are found on many insects, but lacking in Psocoptera. The sterno-pleural muscles are divisible into three kinds by their attached positions, ordinary sterno-pleural muscles connecting the sternum and the episternum, sterno-basalar muscles stretched between the sternum and the basalare, and furco-entopleural muscles stretched between the furca and the pleural ridge or the pleural arm.

a) The ordinary sterno-pleural muscles are found on Phasmidae and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Plecoptera, Embioptera, Jassidae in Hemiptera, Neuroptera, Cicindelidae, and Carabidae in Coleoptera.

b) The sterno-basalar muscles are found in one pair on *Megacrania* (MAKI, 1935) of Phasmidae, Acridiidae and Gryllidae in Orthoptera, Cicadidae, Jassidae and *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, Trichoptera, Plutellidae, Tortricidae, Papilionidae

and Syntomidae in Lepidoptera, *Eutomostethus* of Tenthredinidae and Vespidae in Hymenoptera, and Diptera, in two pairs on Embioptera, Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera, Odonata, Thysanoptera, *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Geometridae and Sphingidae (BERLESE, 1909) in Lepidoptera, Ichneumonidae in Hymenoptera, and in three pairs on Mecoptera.

c) The furco-entopleural muscles are found in one pair on Orthoptera, Dermaptera, Isoptera, Embioptera, Ecdyonuridae in Ephemeroptera, Thysanoptera, Hemiptera, most of Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Dytiscidae (BAUER, 1910) in Coleoptera, *Schizocerus* and *Tenthredo* of Tenthredinidae (WEBER, 1927), Ichneumonidae and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera, Tipulidae in Diptera, and in two pairs on Plecoptera, Neuroptera, Mecoptera, Trichoptera, *Eutomostethus* of Tenthredinidae and *Vespa ducalis* of Vespidae in Hymenoptera, higher Diptera, but lack in *Papilio* (WEBER, 1928) of Papilionidae in Lepidoptera, Psocoptera, Odonata, Cicindelidae, Carabidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera.

8. Pleural Muscles

The pleural muscles are found on Dermaptera. Plecoptera and Trichoptera have muscles resemblant to and probably homologous to the pleural muscles of Dermaptera.

9. Coxal Muscles Coxal and Trochantinal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors are found in one pair on Blattidae, Phasmidae, Acridiidae, Tettigonidae and *Brachytrupes* of Gryllidae in Orthoptera, Dermaptera, Isoptera, Embioptera, Psocoptera, Ephemeroptera, *Crocothemis* of Libellulidae in Odonata, Hemiptera, Neuroptera, Mecoptera, Trichoptera, Plutellidae, Tortricidae, *Papilio* (WEBER, 1928) of Papilionidae and Geometridae in Lepidoptera, Cicindelidae in Coleoptera, and in two pairs on Mantidae and *Gryllus* (VOSS, 1905; DU PORTE, 1920) of Gryllidae in Orthoptera, Plecoptera, *Papilio thaiwanus*, Syntomidae and Sphingidae (BERLESE, 1906) in Lepidoptera, but lack in many Odonata, Thysanoptera, Carabidae, Staphylinidae, Coc-

cinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1010) and Hydrophilidae (BERLESE, 1909) in Coleoptera and Diptera.

The tergal promotors are divisible into two types by their ventral attached positions: One attached on the trochantin, and the other on the coxal rim; the former is found on Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Pentatomidae, Corixidae, Cicadidae and Jassidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Cicindelidae in Coleoptera; the latter is found on Ephemeroptera, Libellulidae in Odonata, Psyllidae in Hemiptera, and Lepidoptera.

(*b*) *Pleural Promotors of the Coxae, and Trochantino-Basalar Muscles*

The pleural promotor arises on the episternum and attaches on the trochantin; the trochantino-basalar muscle is a bundle of fibers stretched between the movable basalar sclerite or the dorso-anterior flexible episternal margin and the trochantin.

Mantidae and *Gryllus* (VOSS, 1905; DU PORTE, 1920) of Gryllidae in Orthoptera have a pair of the pleural promotors and a pair of the trochantino-basalar muscles. Blattidae, Mantidae, Tettigonidae and *Brachytrupes* of Gryllidae in Orthoptera, *Cicada* (BERLESE, 1909) of Hemiptera, Neuroptera and Isoptera have a pair of the trochantino-basalar muscles.

(*c*) *Sternal Promotors of the Coxae*

The sternal promotors may be divided into two kinds by their attached positions: An anterior spinal promotor arising on the median apophysis at the anterior end of the sternum, an ordinary sternal promotor arising on the sternal wall or the furcal arm, both are attached on the anterior coxal basal rim or rarely on the trochantin near the coxal rim.

Psocoptera has only a pair of the anterior spinal promotors. Blattidae, Mantidae, Acridiidae in Orthoptera, Plecoptera, Embioptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, *Crocothemis* of Libellulidae and Agrionidae in Odonata, Thysanoptera, *Nezara* (MALOUF, 1933) of Pentatomidae, Corixidae, *Huechys* of Cicadidae, Jassidae and Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera.

Cicindelidae, Carabidae, Staphylinidae, Tenebrionidae, Chrysomelidae, Scarabaeidae and Dytiscidae (BAUER, 1910) in Coleoptera, Hymenoptera, Tipulidae, Stratiomyidae, *Lathyrophthalmus* of Syrphidae and Micropezidae in Diptera have a pair of the ordinary sternal promotors; Phasmidae in Orthoptera, Ecdyonuridae and Baetidae (DÜRKEN, 1907) in Ephemeroptera, and *Volucella* (BERLESE, 1909) of Syrphidae and Muscidae in Diptera have two pairs of the ordinary sternal promotors.

Tettigonidae and Gryllidae in Orthoptera, Dermaptera and Isoptera have one or two pairs (*Gryllus assimilis*) of the anterior spinal promotors and one pair of the ordinary sternal promotors.

Aeschnidae and Coenagrionidae in Odonata (MALOUF, 1935), *Eurostus* of Pentatomidae and *Cicada* (BERLESE, 1909) of Cicadidae in Hemiptera, and Coccinellidae in Coleoptera lack the sternal promotors.

(*d*) *Tergal Remotors of the Coxae*

The tergal remotors are found in a pair on Labiidae in Dermaptera, *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Thysanoptera, Pentatomidae and Jassidae in Hemiptera, Mecoptera, Trichoptera, Plutellidae, Tortricidae, Geometridae and Sphingidae (BERLESE, 1909) in Lepidoptera, most of Coleoptera, and Diptera, in two pairs on Blattidae, *Megacrania* (MAKI, 1935) of Phasmidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiduridae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ecdyonuridae and *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Corixidae, Cicadidae and *Macrohomotoma* of Psyllidae in Hemiptera, *Papilio thaiwanus* of Papilionidae and Syntomidae in Lepidoptera, and Dytiscidae (BAUER, 1910) in Coleoptera, and in three pairs on Mantidae and *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Ephemeridae (KNOX) in Ephemeroptera, *Papilio* (WEBER, 1928) of Lepidoptera; and Neuroptera, but lack in Odonata, *Psylla* (WEBER, 1929) in Hemiptera, and Hymenoptera.

(*e*) *Coxo-Subalar Muscles*

The coxo-subalar muscles are found in a pair on many winged insects, in two pairs on Psocoptera and *Papilio* (WEBER, 1928) in Le-

pidoptera, but lack in Odonata, Corixidae and *Psylla* (WEBER, 1929) in Hemiptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, Vespidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

(f) Coxo-Axillary Muscles

The coxo-axillary muscles are very special muscles found on only Odonata.

(g) Sternal Remotors of the Coxae

The sternal remotors may be divided into two kinds by their arising positions as in those of the prothorax, posterior spinal remotors and ordinary sternal remotors.

Blattidae in Orthoptera has only a pair of the posterior spinal remotors. *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Locusta* of Acridiidae in Orthoptera, Dermaptera, Plecoptera, Psocoptera, Ecdyonuridae and Baetidae (DÜRKEN, 1907) in Ephemeroptera, *Crocothemis* of Libellulidae, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935) and Agrionidae in Odonata, Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, Trichoptera, Plutellidae, Tortricidae, Papilionidae and Syntomidae in Lepidoptera, Cicindelidae, Carabidae, Staphylinidae, Tenebrionidae, Chrysomelidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and *Vespa ducalis* in Hymenoptera, and many higher Diptera have only a pair of the ordinary sternal remotors; *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Embioptera, Thysanoptera, Geometridae in Lepidoptera, Coccinellidae and Dytiscidae (BAUER, 1910) in Coleoptera, *Schizocerus* and *Tenthredo* of Tenthredinidae (WEBER, 1927) and *Vespa crabro* (WEBER, 1926) of Vespidae in Hymenoptera and Tipulidae in Diptera have two pairs of the ordinary sternal remotors.

Mantidae, *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, and Isoptera have a pair of the posterior spinal remotors and a pair of the ordinary sternal remotors.

(*h*) *Pleural Adductors of the Coxae*

The pleural adductors are found in a pair on Phasmidae in Orthoptera, but lacking in many other insects.

(*i*) *Sternal adductors of the coxae*

The sternal adductors are found in a pair on Blattidae, Mantidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Plecoptera and Embioptera, but lacking in many others.

(*j*) *Tergal Abductors of the Coxae*

Locusta of Acridiidae in Orthoptera, *Papilio* (WEBER, 1928) in Lepidoptera, Carabidae, Scarabaeidae and Dytiscidae (BAUER, 1910) in Coleoptera have a pair of tergal abductors of the coxae, but many other insects lack the tergal abductors.

(*k*) *Pleural Abductors of the Coxae, and Coxo-Basalar Muscles*

The pleural abductors are muscles connecting the episterna, the pleural ridges or the epimera (*Schizocerus* of Tenthredinidae, WEBER, 1927) with the antero-lateral basal rims of the coxae. The coxo-basalar muscles are wing muscles attached dorsrlly on the basalar sclerites of the dorsal or anterior flexible marginal portions of the episterna and ventrally on the anterior or antero-lateral basal rims of the coxae. The latter are muscles probably derived from the former.

In pterygote insects there are found several types as follows:

I. Insects provided with only the pleural abductors: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Gryllus* (VOSS, 1909; DU PORTE, 1920) in Orthoptera, Labiduridae in Dermaptera, Ecdyonuridae and *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Odonata, Thysanoptera, *Eurostus* of Pentatomidae, Corixidae and Psyllidae in Hemiptera, Cicindelidae, Carabidae, Staphylinidae, Scarabaeidae and Dytiscidae (BAUER, 1910) in Coleoptera, Tenthredinidae and Ichneumonidae in Hymenoptera.

II. Insects provided with only the coxo-basalar muscles: Trichoptera.

III. Insects provided with both the pleural abductors and the coxo-basalar muscles: Orthoptera except *Gryllus*, Labiidae in Der-

maptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeridae (KNOX, 1935) and *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, *Huechys* of Cicadidae and Jassidae in Hemiptera, Neuroptera, Mecoptera, Lepidoptera, Coccinellidae, Tenebrionidae, Chrysomelidae and Hydrophilidae (BERLESE, 1909) in Coleoptera.

IV. Insects having neither pleural abductor nor coxo-basalar muscle: Vespidae in Hymenoptera, and Diptera.

The pleural abductors are one-paired in Labiidae in Dermaptera, Plecoptera, Embioptera, Ephemeroptera, Odonata, Thysanoptera, Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, Lepidoptera, Coleoptera and Hymenoptera, two-paired in Blattidae, Mantidae, *Locusta* and *Atractomorpha* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiduridae in Dermaptera, Psocoptera, and the Hydrophilidae (BERLESE, 1909) in Coleoptera, and three-paired in *Megacrania* (MAKI, 1935) of Phasmidae and *Dissosteira* (SNODGRASS, 1929) ot Acridiidae in Orthoptera, and Isoptera.

The coxo-basalar muscles are one-paired on Blattidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeroptera, Cicadidae and Jassidae in Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, Trichoptera, Lepidoptera, Coccinellidae, Tenebrionidae, Chrysomelidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, and two-paired in Mantidae and *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera.

10. Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles

(a) Tergal Depressors of the Trochanters

The tergal depressors are found in one pair on many insects, exceptionally in two-pairs on *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Papilionidae, Geometridae, Syntomidae and Sphingidae (BERLESE, 1909) in Lepidoptera, in three pairs on Dytiscidae in Coleoptera, but lack in Odonata, Thysanoptera, Psyllidae in Hemiptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, Hymenoptera, Tipulidae in Diptera.

(*b*) *Pleural Depressors of the Trochanters, and Trochantero-Basalar Muscles*

The pleural depressors are muscles arising on the episterna or very rarely on the epimera (Chrysomelidae, Scarabaeidae and Hydrophilidae in Coleoptera) and attached on the ventral bases of the trochanters. The trochantero-basalar muscles are bundles of fibers attached dorsally on the basalar sclerites or the dorsal flexible marginal portions of the episterna and ventrally on the ventral bases of the trochanters. The latter are wing muscles derived from the former.

Dixippus (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Labiduridae in Dermaptera, Ephemeroptera, Odonata, Pentatomidae and Jassidae in Hemiptera, Cicindelidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, and Tipulidae in Diptera have one pair of the pleural depressors of the trochanters; Corixidae in Hemiptera and Carabidae in Coleoptera have two pairs of the pleural depressors of the trochanters; Hydrophilidae (BERLESE, 1909) has three pairs of the pleural depressors of the trochanters.

Blattidae in Orthoptera has two pairs of the trochantero-basalar muscles; Mantidae, *Megacrania* (MAKI, 1935) of Phasmidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeridae (KNOX, 1935) and *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Cicadidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, and most of Lepidoptera have one pair of the trochantero-basalar muscles.

Acridiidae in Orthoptera, Thysanoptera, Psyllidae in Hemiptera, *Papilio* (WEBER, 1928) in Lepidoptera, Hymenoptera, Stratiomyidae, *Lathyro phthalmus* of Syrphidae, Micropezidae and Muscidae in Diptera lack both the pleural depressors and the trochantero-basalar muscles.

(*c*) *Sternal Depressors of the Trochanters*

The sternal depressors are found in a pair on many insects, but are lacking in Phasmidae in Orthoptera, Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera, and Scarabaeidae in Coleoptera.

(*d*) *Pleural Levators of the Trochanters*

The pleural levators are found in a pair on only higher Diptera.

11. Muscles of the First Thoracic Spiracles

The number of the muscles and their attached positions in the first thoracic spiracles varies in different insects. The first thoracic spiracles may be classified into several types by the number of these muscles and their attached positions:

I. A spiracle provided with an occlusor attached on the end of the slit-like opening of the spiracle. The spiracles of this type may be subdivided by the arising positions of the muscles as follows:

i. A spiracle provided with an occlusor arising on the subspiraculare. The spiracle of this type is found on Blattidae in Orthoptera, Isoptera, Embioptera, Psocoptera, Hemiptera, Neuroptera, Trichoptera, Carabidae, Staphylinidae, Tenebrionidae, Coccinellidae, Chrysomelidae and Scarabaeidae in Coleoptera,

ii. A spiracle provided with an occlusor arising on the mesepisternum. The spiracle of this type is found on Tettigonidae in Orthoptera, *Crocothemis* of Libellulidae in Odonata, and Thysanoptera.

iii. A spiracle provided with an occlusor arising on the protergal sclerite. The spiracle of this type is found on *Eutomostethus* of Tenthredinidae in Hymenoptera.

iv. A spiracle provided with an occlusor arising on the anterolateral portion of the sternal region. The spiracle of this type is found on Ecdyonuridae in Ephemeroptera, and Agrionidae in Odonata.

v. A spiracle provided with an occlusor attached dorsally on the closing rod of the spiracle at the anterior lip of the spiracle, and ventrally on the under side of the spiracle. The spiracle of this type is found on all Lepidoptera, and on Cicindelidae in Coleoptera also.

vi. A spiracle provided with an occlusor arising on the lateral intersegmental ridge. The spiracle of this type is found on Mecoptera, Ichneumonidae and Vespidae in Hymenoptera, Tipulidae and Stratiomyidae in Diptera.

vii. A spiracle provided with an occlusor arising on the pro-

pleuron. The spiracle of this type is found on Syrphidae, Micropezidae and Muscidae in Diptera.

II. A spiracle provided with two muscles. The spiracles of this type may be divided into two kinds by the attached positions of the muscles:

i. A spiracle provided with the occlusors arising on the subspiraculare. The spiracles of this type may be divided into two:

a) A spiracle provided with two occlusors attached dorsally on the ventral end of the spiracle. The spiracles of this type are found on Phasmidae in Orthoptera, Dermaptera and Plecoptera.

b) A spiracle provided with two occlusors, one attached dorsally on the septum between the two tracheal openings, the other dorsally on the anterior lip of the spiracle, and both cruciate to each other. The spiracle of this type is found on Mantidae in Orthoptera.

ii. A spiracle provided with an occlusor and a dilator, the former attached on the septum between the two tracheal openings, the latter on the posterior lip of the spiracle, both arising on the ventral portion of the subspiraculare. The spiracle of this type is found on Acridiidae and *Brachytrupes* of Gryllidae in Orthoptera. The first thoracic spiracle in *Dissosteira* described by SNODGRASS (1935) belongs to this type.

c. Metathoracic Muscles

1. Dorsal Muscles

The metathoracic dorsal muscles may be classified as follows:

a) Median dorsal muscles.

i) Median internal dorsal muscles.

ii) Median external dorsal muscles.

iii) Median dorsal muscles undivided into internals and externals.

b) Lateral dorsal muscles.

i) Lateral internal dorsal muscles.

ii) Lateral external dorsal muscles.

iii) Lateral dorsal muscles undivided into internals and externals.

c) Common dorsal muscles of the metathorax and the first abdominal segment.

Pterygote insects may be classified by the dorsal muscles as follows:

I. Insects provided with only the median dorsal muscles.

i. Insects provided with the median internal and the median external dorsal muscles: *Atractomorpha* of Acridiidae in Orthoptera.

ii. Insects provided with median dorsal muscles undivisible into internals and externals: *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Ecdyonuridae, Ephemeridae (KNOX, 1935) and *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Pentatomidae, Cicadidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Ichneumonidae and Vespidae in Hymenoptera.

II. Insects provided with only the lateral dorsal muscles undivisible into internals and externals: Agrionidae in Odonata, and Thysanoptera.

III. Insects provided with both the median and the lateral dorsal muscles:

i. Insects provided with the median internal, the median external, the lateral internal and the lateral external dorsal muscles: Blattidae and *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Neuroptera.

ii. Insects provided with the median dorsal muscles undivisible into internals and externals, the lateral internal and the lateral external dorsal muscles: Labiduridae in Dermaptera, and Isoptera.

iii. Insects provided with the median and the lateral dorsal muscles undivisible into internals and externals: Mantidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Psocoptera, Jassidae in Hemiptera, Mecoptera, most of Lepidoptera, and Coleoptera.

iv. Insects provided with the median internal and the median external dorsal muscles and the lateral dorsal muscles undivisible into internals and externals: *Gryllus domesticus* (VOSS, 1905) in Orthoptera, Embioptera, Sphingidae in Lepidoptera, Trichoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera.

v. Insects provided with the median dorsal muscles undivided

into internals and externals and the common dorsal muscles of the metathorax and first abdominal segment: *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera.

vi. Insects lacking the dorsal muscles: *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Libellulidae, Aeschnidae (MALOUF, 1935) and Coenagrionidae (MALOUF, 1935) in Odonata, Corixidae and *Macrohomotoma* of Psyllidae in Hemiptera, and Diptera.

2. Dorsal Transverse Muscles

Blattidae and Mantidae in Orthoptera, Isoptera and Diptera have one pair of dorsal transverse muscles similar to the mesothoracic dorsal transverse muscles in Blattidae, but many other pterygote insects lack the dorsal transverse muscles.

3. Ventral Muscles

The ventral muscles may be classified into eight types as follows:

a) Longitudinal ventral muscles attached anteriorly on the mesofurca or the metapresternum, and posteriorly on the metafurca. This type corresponds to the a-type of the mesothoracic ventral muscles.

b) Unpaired longitudinal median ventral muscle arising on the spina at the anterior end of the sternum and attached on the posterior end of the median portion of the sternum. This type corresponds to the b-type of the mesothoracic ventral muscles.

c) Oblique slender ventral muscles arising on the spina at the anterior end of the sternum and attached on the metafurcal arms. This type corresponds to the c-type of the mesothoracic ventral muscles.

The ventral muscles of two preceding types as well as the ventral muscles of the b-, c-, d- and e-type in the mesothorax are morphologically interesting muscles, may be called spinal ventral muscles to be different from the other ventral muscles. In chilopods and apterygote insects, the ventral transverse muscles are representative bundles of fibers running over the connectives of the ventral nerve cord. In the muscles having the same character in pterygote insects there are found two kinds; the ventral transverse muscles, and spinal ventral muscles except the median unpaired longitudinal spinal muscles

situated between the connectives of ventral nerve cord. The ventral transverse muscles in pterygote insects often diverge and form the common net of ventral transverse muscles extending from the thorax to the abdomen. From these facts, it seems to be possible that all the forms such as the spinal ventral muscles found on the mesothorax (the b-, c-, d- and e-type of ventral muscles) and the metathorax (the b- and c-type of ventral muscles) are readily derived from the ventral transverse muscles.

d) Oblique muscles arising on the antero-lateral corners of the metasternum and attached on the metafurcal arms. This type corresponds to the f-type of the mesothoracic ventral muscles.

e) Posterior ventral muscles arising on the metafurcal arms and attached to the anterior end of the first abdominal sternum. The muscles of this type probably correspond to the muscles of the h-type in the mesothoracic ventral muscles.

f) Longitudinal muscles arising on the mesofurca and attached on the anterior end of the first abdominal sternum.

g) Very long slender ventral muscles (common ventrals of the mesothorax and metathorax) arising on the profurca and attached to the anterior end of the first abdominal sternum.

h) Very long muscles (common ventral muscles of the meso-, metathorax, and first abdominal segment) arising on the profurca and attached to the anterior end of the second abdominal sternum.

i) Oblique muscles (common ventral muscles of the metathorax and first abdominal segment) arising on the metaspina at the anterior end of the metasternum and attached to the anterior end of the second abdominal sternum.

Pterygote insects will be divisible by the ventral muscles as follows:

I. Insects provided with the muscles of e-type: Phasmidae in Orthoptera, Psocoptera, Ecdyonuridae in Ephemeroptera, *Eurostus* of Pentatomidae, Corixidae, Cicadidae and Jassidae in Hemiptera, Mecoptera, Trichoptera, Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1910)

and Hydrophilidae (BERLESE, 1909) in Coleoptera, *Eutomostethus* and *Schizocerus* (WEBER, 1927) of Tenthredinidae, Ichneumonidae and Vespidae in Hymenoptera, and Diptera. These muscles are one-paired in many cases, rarely two-paired as in *Papilio* (WEBER, 1928), Geometridae and Syntomidae in Lepidoptera, and Stratiomyidae in Diptera.

II. Insects provided with muscles of a-, b- and c-type: Blattidae in Orthoptera.

III. Insects provided with the muscles of a- and c-type: Mantidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Cicindelidae and Carabidae in Coleoptera, *Tenthredo* (WEBER, 1927) in Hymenoptera.

IV. Insects provided with the muscles of a- and d-type: Neuroptera.

V. Insects provided with the muscles of a-, c- and d-type: Labiduridue in Dermaptera.

VI. Insects provided with the muscles of a-, e-, and f-type: Thysanoptera.

VII. Insects provided with the muscles of e- and g-type: *Crocothemis* of Libellulidae and Agrionidae in Odonata.

VIII. Insects provided with only the muscles of e-type: *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera.

IX Insects provided with the muscles of e- and h-type: *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera.

X. Insects provided with the muscles of a-, c-, and i-type: *Periplaneta orientalis* (MIALL and DENNY, 1886).

XI. Insects provided with the muscles of e-type: *Diplax* (BERLESE, 1909) of Libellulidae, Aeschnidae (MALOUF, 1935) and Coenagrionidae (MALOUF, 1935) in Odonata.

XII. Insects lacking the ventral muscles: *Atractomorpha* in Orthoptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, *Nezara* (MALOUF, 1933) of Pentatomidae and Psyllidae in Hemiptera.

4. Ventral Transverse Muscles

The metathoracic ventral transverse muscles may be classified as follows:

a) Anterior ventral transverse muscles arising on the ventro-lateral portion of the anterior end of the sternal region and attached on the median apophysis between the meso- and metasternum.

b) Posterior ventral transverse muscles stretched between the furcal arms of both sides.

These types correspond to the mesothoracics, ai- and bii-type, respectively. The aii- and bi-type in the mesothoracic ventral transverse muscles are not found on the metathorax.

In pterygote insects there are found four types as follows:

I. Insects provided with only the anterior ventral transverse muscles: Blattidae, Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera and Isoptera.

II. Insects provided with only the posterior ventral transverse muscles: *Megacrania* (MAKI, 1935) of Phasmidae and *Atractomorpha* of Acridiidae in Orthoptera, Ephemeroptera, and Tipulidae in Diptera.

III. Insects provided with both the anterior and the posterior ventral transverse muscles: *Locusta* of Acridiidae in Orthoptera, Neuroptera and Mecoptera.

IV. Insects lacking the ventral transverse muscles: Mantidae, *Dixippus* (JEZIORSKI, 1918) of Phasmidae and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Labiduridae in Dermaptera, Embioptera, Psocoptera, Odonata, Thysanoptera, Hemiptera, Trichoptera, Lepidoptera, Coleoptera, Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

5. Tergo-Sternal Muscles

The metathoracic tergo-sternal muscles may be divided into four kinds as in the mesothoracics:

a) Anterior tergo-sternal muscles.

b) Posterior tergo-sternal muscles. These include the intersegmental tergo-sternal muscles similar to the posterior tergo-sternal mus-

cles in the mesothorax, and also the alinoto-furcal muscles found on *Hexagenia* (III Dvm, KNOX, 1935), *Centroptilum* (III Dvm 5) and *Ephemerella* (III dvm 7) (DÜRKEN, 1907) in Ephemeroptera, and *Psylla mali* (III ism 1, WEBER, 1929) in Hemiptera.

c) Sterno-subalar muscles.

d) Sterno-axillary muscles.

The muscles in each kind are one-paired in many cases; but the anterior tergo-sternal muscles in Plecoptera, Embioptera, Odonata, Thysanoptera and Neuroptera, ahd the posterior tergo-sternal muscles in Coccinellidae, Tenebrionidae and Scarabaeidae in Coleoptera are two-paired.

Pterygote insects will be divisible by the muscles as follows:

I. Insects provided with only the anterior tergo-sternal muscles: *Dissosteira* of Acridiidae in Orthoptera, Mecoptera, Papilionidae, Geometridae, Syntomidae and Sphingidae (BERLESE, 1909) in Lepidoptera, and Diptera.

II. Insects provided with only the posterior tergo-sternal muscles: Blattidae, Mantidae and Gryllidae in Orthoptera, Labiduridae in Dermaptera, Isoptera, Psocoptera, Pentatomidae in Hemiptera.

III. Insects provided with the anterior tergo-sternal and posterior tergo-sternal muscles: Phasmidae and Acridiidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Embioptera, *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Odonata, Thysanoptera, Cicadidae, Jassidae and Psyllidae in Hemiptera, Neuroptera, Trichoptera, Plutellidae and Tortricidae in Lepidoptera, Coleoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera.

IV. Insects provided with the anterior tergo-sternal muscles, sterno-subalar muscles and sterno-axillary muscles: Ecdyonuridae in Ephemeroptera.

V. Insects provided with anterior tergo-sternal muscles, the sterno-basalar muscles, and the posterior tergo-sternal muscles: *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera.

VI. Insects provided with the anterior tergo-sternal muscles, the

sterno-axillary muscles, and posterior tergo-sternal muscles: Ephemeridae (KNOX, 1935) in Ephemeroptera.

VII. Insects lacking the tergo-sternal muscles: Corixidae in Hemiptera, Ichneumonidae and Vespidae in Hymenoptera.

6. Tergo-Pleural Muscles

The Metathoracic tergo-pleural muscles may be divided into three kinds as in the mesothoracic ones: Ordinary tergo-pleural muscles, pleuro-axillary muscles and pleuro-subalar muscles.

A. Ordinary tergo-pleural muscles may be subdivided into two kinds:

1) Anterior tergo-pleural muscles.

2) Posterior tergo-pleural muscles.

Pterygote insects may be classified into four types by the ordinary tergo-pleural muscles:

I. Insects provided with only the anterior tergo-pleural muscles: Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Ecdyonuridae (KNOX, 1935) in Ephemeroptera, Odonata, *Macrohomotoma* of Psyllidae in Hemiptera, Coleoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

II. Insects provided with only the posterior tergo-pleural muscles: *Huechys* of Cicadidae and Jassidae in Hemiptera, Ichneumonidae and Vespidae in Hymenoptera.

III. Insects provided with both the anterior and the posterior tergo-pleural muscles: Blattidae, Mantidae, Phasmidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Thysanoptera, Neuroptera, Mecoptera, Trichoptera, most of Lepidoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera, and Tipulidae in Diptera.

IV. Insects lacking the ordinary tergo-pleural muscles: *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Atractomorpha* of Acridiidae in Orthoptera, Pentatomidae, Corixidae, *Cicada* (BERLESE, 1909) of Cicadidae and *Psylla* (WEBER, 1929) of Psyllidae in Hemiptera, Sphingidae

(BERLESE, 1909) and *Papilio* (WEBER, 1928) of Papilionidae in Lepidoptera.

The anterior tergo-pleural muscles are one-paired in Mantidae, Tettigonidae, *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae in Orthoptera, Labiidae in Dermaptera, Isoptera, Embioptera, Odonata, Thysanoptera, Psyllidae in Hemiptera, Plutellidae, Tortricidae, Geometridae and Syntomidae in Lepidoptera, Cicindelidae in Coleoptera, and Tipulidae in Diptera, two-paired in Blattidae and *Locusta* of Acridiidae in Orthoptera, Labiduridae in Dermaptera, Plecoptera, Psocoptera, Ecdyonuridae in Ephemeroptera, *Papilio thaiwanus* in Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, Tenthredinidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera, three-paired in *Megacrania* (MAKI, 1935) of Phasmidae and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Ephemeridae (KNOX, 1935) in Ephemeroptera, Neuroptera (MAKI, 1936), Mecoptera and Trichoptera.

The posterior tergo-pleural muscles are one-paired in *Locusta* and *Gryllus domesticus* (VOSS, 1905) in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Thysanoptera, Cicadidae and Jassidae in Hemiptera, Mecoptera, Trichoptera, Tortricidae, Papilionidae, Geometridae and Syntomidae in Lepidoptera, Tenthredinidae and Vespidae in Hymenoptera, Tipulidae in Diptera, and two-paired in Blattidae, Mantidae and Phasmidae in Orthoptera, Psocoptera, Neuroptera, Plutellidae in Lepidoptera, Ichneumonidae in Hymenoptera.

B. The metathoracic pleuro-axillary muscles are found in one pair on Blattidae, Mantidae, *Locusta* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ephemeridae (KNOX, 1935) and Baetidae (DÜRKEN, 1907) in Ephemeroptera, Libellulidae in Odonata, Thysanoptera, Pentatomidae, *Cicada* (BERLESE, 1909) of Cicadidae in Hemiptera, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, Ichneumonidae and Vespidae in

Hymenoptera, and Diptera, in two pairs on *Megacrania* (MAKI, 1935) of Phasmidae and *Atractomorpha* of Acridiidae in Orthoptera, Ecdyonuridae in Ephemeroptera, Aeschnidae (MALOUF, 1935), Coenagrionidae (MALOUF, 1935) and Agrionidae in Odonata, Corixidae, *Huechys* of Cicadidae and *Macrohomotoma* of Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Carabidae, Staphylinidae, Tenebrionidae and Scarabaeidae in Coleoptera, and *Eutomostethus* of Tenthredinidae in Hymenoptera, in three pairs on Cicindelidae and Coccinellidae in Coleoptera, and in four pairs on Chrysomelidae in Coleoptera, but lacking in wingless insects (as *Dixippus* (JEZIORSKI, 1918) of Phasmidae, and Labiduridae).

The pleuro-axillary muscles divide their origins into two as in the mesothoracics, one on the episterna, and the other on the pleural ridges or the epimera along the pleural ridges, or rarely on the pleural wing processes. Those of Blattidae in Orthoptera, Plecoptera, Embioptera, Pentatomidae and *Macrohomotoma* of Psyllidae in Hemiptera, Sphingidae (BERLESE, 1909) in Lepidoptera, Ichneumonidae and Vespidae in Hymenoptera take their origins on the first. Those of Mantidae, Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Isoptera, Psocoptera, Ephemeroptera, Odonata, Thysanoptera, Corixidae, Cicadidae and Jassidae in Hemiptera, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, and Diptera take their origins on the second. *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Neuroptera (MAKI, 1936), Mecoptera, Trichoptera, most of Lepidoptera, Cicindelidae, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera have the pleuro-axillary muscles arising on both the first and second.

The pleuro-axillary muscles may be divided into four kinds by the dorsal attached positions:

a) Muscles attached on the axillary plates.

b) Muscles attached on the posterior basal portions of the halters.

c) Muscles attached on the first axillary sclerites.

d) Muscles attached on the third axillary sclerites.

The first type is found on Odonata, second on Diptera, the fourth on many winged insects. *Macrohomotoma* in Hemiptera and *Ecdyonurus* in Ephemeroptera have both the third and the fourth muscles.

C. The metathoracic pleuro-subalar muscles are bundles arising on the epimera and attached on the subalar sclerites or membranes, and corresponding to the first type of mesothoracic pleuro-subalar muscles (C. 1). These are found in a pair on *Megacrania* (MAKI, 1935) of Phasmidae, Tettigonidae and Gryllidae in Orthoptera, Plecoptera, Embioptera, Neuroptera, Cicindelidae, Carabidae, Staphylinidae, Coccinellidae, Chrysomelidae and Scarabaeidae in Coleoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and Vespidae in Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera, in two pairs on Mecoptera, and in three pairs on Odonata, but lacking in many other insects.

7. Sterno-Pleural Muscles

The metathoracic sterno-pleural muscles are found on many insects as in the mesothoracics, but lacking in Labiidae in Dermaptera, Psocoptera, Pentatomidae, Corixidae and Jassidae in Hemiptera. These muscles may be divided into four kinds by their attached positions: ordinary sterno-pleural muscles, sterno-basalar muscles, furco-entopleural muscles, and sterno-entopleural muscles. The first three correspond to those in the mesothorax respectively. The last muscles arise on the posterior sternal plates and attach on the pleural ridges, and are bundles probably homologous to the furco-entopleural muscles.

a) The ordinary sterno-pleural muscles are found in one pair on Phasmidae in Orthoptera, Plecoptera, Embioptera, *Huechys* of Cicadidae in Hemiptera, Trichoptera, Tenthredinidae and Ichneumonidae in Hymenoptera, and in two pairs in Neuroptera.

b) The sterno-basalar muscles are found in a pair on *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Plecoptera, Psyllidae in Hemiptera, Neuroptera and Coleoptera, *Schizocerus* (WEBER, 1927) of Tenthredinidae and Vespidae in Hymenoptera; Diptera, in two pairs on *Locusta* and *Atractomorpha* of Acridiidae in Orthoptera, Embioptera, Odonata, Mecoptera, many Lepidoptera, and Tenthredinidae in Hyme-

noptera, and in three pairs on *Megacrania* (MAKI, 1935) of Phasmidae in Orthoptera, Thysanoptera, Ichneumonidae in Hymenoptera.

c) The furco-entopleural muscles are found in a pair on Orthoptera, Labiduridae in Dermaptera, Isoptera, Embioptera, Ecdyonuridae in Ephemeroptera, Thysanoptera, Cicadidae and *Macrohomotoma* of Psyllidae in Hemiptera, Trichoptera, many Lepidoptera, Coleoptera, and Ichneumonidae in Hymenoptera, and in two pairs on Plecoptera, Neuroptera, Mecoptera, *Eutomostethus* of Tenthredinidae in Hymenoptera, and Diptera. Labiidae in Dermaptera, Psocoptera, Odonata, Pentatomidae, Corixidae and Jassidae in Hemiptera, Vespidae in Hymenoptera lack the furco-entopleural muscles, but the muscles in the last are displaced by the tendinous bridges. The ventral furco-entopleural muscles (stretched between the furca and the ventral portions of the pleural ridges) found on the pterothorax in Plecoptera, Neuroptera, Mecoptera, Trichoptera, *Eutomostethus* of Tenthredinidae, higher Diptera, on the mesothorax in the Vespidae, and on the metathorax in Coleoptera, lower Diptera, etc. are not found on the hemimetabolous insects in general, might be probably modified bundles of fibers homologous to the sternal remotors of the coxae.

d) The sterno-entopleural muscles are found in a pair on Thysanoptera.

8. Pleural Muscles

The metathoracic pleural muscles are found in a pair on Dermaptera. The muscles resembling the pleural muscles in Dermaptera are present on Psocoptera, Trichoptera, Staphylinidae, Coccinellidae, Chrysomelidae, Scarabaeidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera.

9. Coxal Muscles, Coxal and Trochantinal Wing Muscles

(*a*) *Tergal Promotors of the Coxae*

The tergal promotors are present in a pair on many pterygote insects, but in two pairs on Mantidae and Gryllidae in Orthoptera, Plecoptera, *Eurostus* of Pentatomidae in Hemiptera, in three pairs on *Nezara* (MALOUF, 1933) of Pentatomidae. *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Psocoptera, Agrionidae, Coenagrionidae

(MALOUF, 1935) and Aeschnidae (MALOUF, 1935) in Odonata, Thysanoptera, Psyllidae in Hemiptera, Cicindelidae, Carabidae, Scarabaeidae, Dytiscidae (BAUER, 1910) and Hydrophilidae (BERLESE, 1909) in Coleoptera, Hymenoptera and Diptera lack the tergal promotors.

The tergal promotors are divisible into two types by their ventral attached portions as in the mesothorax:

I. Insects provided with the tergal promotors attached on the trochantin: Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, Pentatomidae, Cicadidae and Jassidae in Hemiptera, Neuroptera (MAKI, 1936), Mecoptera and Trichoptera.

II. Insects provided with the tergal promotors attached on the coxal basal rim: Ephemeroptera, Libellulidae in Odonata, Corixidae in Hemiptera, Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae and Chrysomelidae in Coleoptera.

(*b*) *Pleural Promotors of the Coxae, and Trochantino-Basalar Muscles*

On the metathorax are found pleural promotors of the coxae and trochantino-basalar muscles as in the mesothorax.

Insects provided with a pair of pleural promotors are Mantidae and *Gryllus* in Orthoptera, Labiduridae in Dermaptera, *Eurostus* of Pentatomidae and Cicadidae in Hemiptera.

Insects provided with a pair of trochantino-basalar muscles are Blattidae, Mantidae, Tettigonidae and Gryllidae in Orthoptera, Labiidae in Dermaptera, Isoptera and Neuroptera.

(*c*) *Sternal Promotors of the Coxae*

The sternal promotors may be divided into three kinds by their arising positions, anterior mesofurcal promotors, anterior spinal promotors and ordinary sternal promotors. The first are muscles arising on the mesofurca, and attached on the anterior basal portions of the coxae. The second and third muscles correspond to the anterior spinal promotors and the ordinary sternal promotors in the mesothorax respectively. The anterior mesofurcal promotors may be bundles derived from the anterior spinal promotors.

Pterygote insects will be divisible into four types by the sternal promotors:

I. Insects provided with only the anterior mesofurcal promotors: Psocoptera and Agrionidae in Odonata.

II. Insects provided with only the ordinary sternal promotors: Blattidae, Mantidae, Phasmidae, *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae in Orthoptera, Plecoptera, Embioptera, Ephemeroptera, Thysanoptera, Pentatomidae, Corixidae, Cicadidae and Jassidae in Hemiptera, Neuroptera (MAKI, 1936), Mecoptera, Trichoptera, Tortricidae, Papilionidae, Geometridae and Syntomidae in Lepidoptera, most of Coleoptera, Tenthredinidae and Vespidae in Hymenoptera and Diptera.

III. Insects provided with both the anterior spinal promotors and the ordinary sternal promotors: *Locusta* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Isoptera, and Ichneumonidae in Hymenoptera.

IV. Insects lacking the sternal promotors: Libellulidae, Aeschnidae (MALOUF, 1935) and Coenagrionidae (MALOUF, 1935) in Odonata, Psyllidae in Hemiptera, Plutellidae in Lepidoptera, Dytiscidae (BAUER, 1910) in Coleoptera.

The bundles in each kind of the muscles are one-paired in many cases, but the ordinary sternal promotors in *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Locusta* and *Atractomorpha* of Acridiidae in Orthoptera, Ecdyonuridae and *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Thysanoptera, and Hydrophilidae (BERLESE, 1909) in Coleoptera are often two-paired.

(d) Tergal Remotors of the Coxae

The tergal remotors are found in a pair on Labiidae in Dermaptera, Ephemeridae (KNOX, 1935) and *Centroptilum* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Thysanoptera, Corixidae and *Macrohomotoma* of Psyllidae in Hemiptera, Mecoptera, Trichoptera, Lepidoptera, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, in two pairs on Blattidae, *Megacrania* (MAKI, 1935) of Phasmidae, *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae, and *Brachytrupes* and *Gryllus assimilis* (DU PORTE, 1920) of Gryllidae

in Orthoptera, Labiduridae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Ecdyonuridae and *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Pentatomidae, Cicadidae and Jassidae in Hemiptera, and Cicindelidae in Coleoptera, and in three pairs on Mantidae, *Dixippus* (JEZIORSKI, 1918) of Phasmidae, *Locusta* of Acridiidae and *Gryllus domesticus* (VOSS, 1905) of Gryllidae in Orthoptera, Neuroptera, and Dytiscidae (BAUER, 1910) in Coleoptera, but lacking in Odonata, *Psylla* (WEBER, 1929) in Hemiptera, Hymenoptera and Diptera.

(*e*) *Coxo-Subalar Muscles*

The coxo-subalar muscles are found in a pair on many winged insects, but lacking in Ecdyonuridae in Ephemeroptera, Odonata, Corixidae and *Psylla* (WEBER, 1929) in Hemiptera, *Vespa crabro* (WEBER, 1926) in Hemiptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera.

(*f*) *Coxo-Axillary Muscles*

The coxo-axillary muscles are found on only Odonata as in its Mesothorax.

(*g*) *Sternal Remotors of the Coxae*

The metathoracic sternal remotors are ordinary sternal remotors of the coxae. These are one-paired in Mantidae and *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Dermaptera, Plecoptera, Psocoptera, Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera, Odonata, Pentatomidae Cicadidae and Psyllidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Tortricidae, Papilionidae and Syntomidae in Lepidoptera, most of Coleoptera, *Eutomostethus* of Tenthredinidae, Ichneumonidae and Vespidae in Hymenoptera and Diptera, two-paired in Blattidae, *Megacrania* (MAKI, 1935) of Phasmidae, *Locusta* and *Atractomorpha* of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Isoptera, Embioptera, Thysanoptera, Geometridae in Lepidoptera, and *Schizocerus* and *Tenthredo* of Tenthredinidae (WEBER, 1927) in Hymenoptera, and three-paired in *Dissosteira* (WEBER, 1929) of Acridiidae in Orthoptera, but lacking in Baetidae in Ephemeroptera, Corixidae and Jassidae in Hemiptera, Plutellidae in Lepidoptera, and Carabidae in Coleoptera.

(*h*) *Pleural Adductors of the Coxae*

The pleural adductors are found in a pair on only Phasmidae.

(*i*) *Sternal Adductors of the Coxae*

The sternal adductors are found in one pair on Blattidae, Mantidae, *Atractomorpha* and *Dissosteira* (SNODGRASS, 1929) of Acridiidae, Tettigonidae and Gryllidae in Orthoptera, Dermaptera, Plecoptera, Embioptera, and Carabidae in Coleoptera, in two pairs on *Locusta* of Acridiidae in Orthoptera, but lacking in many other insects.

(*j*) *Tergal Abductors of the Coxae*

The tergal abductors are one-paired in *Ephemerella* (DÜRKEN, 1907) of Baetidae in Ephemeroptera, Carabidae, Staphylinidae, Tenebrionidae, Scarabaeidae and Hydrophilidae (BERLESE, 1909) in Coleoptera, but lacking in many other insects.

(*k*) *Pleural Abductors of the Coxae, and Coxo-Basalar Muscles*

The pleural abductors and the coxo-basalar muscles are similar to those of the mesothorax in their features.

Pterygote insects may be classified by these muscles as follows:

I. Insects provided with only the pleural abductors: *Dixippus* (JEZIORSKI, 1918) of Phasmidae and *Gryllus* (VOSS, 1905; DU PORTE, 1920) in Orthoptera, Labiduridae in Dermaptera, Ephemeroptera, Odonata, Thysanoptera, *Eurostus* of Pentatomidae, *Huechys* of Cicadidae and Jassidae in Hemiptera, Staphylinidae, Coccinellidae and Scarabaeidae in Coleoptera, *Tenthredo* (WEBER, 1927), Ichneumonidae and *Vespa ducalis* in Hymenoptera, and Tipulidae, Syrphidae, Micropezidae and Muscidae in Diptera.

II. Insects provided with only the coxo-basalar muscles: Carabidae in Coleoptera, and *Eutomostethus* of Tenthredinidae in Hymenoptera.

III. Insects provided with both the pleural abductors and coxo-basalar muscles: Many winged Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Tenebrionidae, Chrysomelidae and Hydrophilidae (BERLESE, 1909) in Coleoptera.

IV. Insects lacking both muscles: Corixidae and Psyllidae in

Hemiptera, Cicindelidae and Dytiscidae (BAUER, 1910) in Coleoptera, *Vespa crabro* (WEBER, 1926) in Hymenoptera, and Stratiomyidae in Diptera.

The pleural abductors are one-paired in Labiidae in Dermaptera, Plecoptera, Embioptera, Ephemeroptera, Odonata, Thysanoptera, Pentatomidae, Cicadidae and Jassidae in Hemiptera, Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Staphylinidae, Coccinellidae, Tenebrionidae, Chrysomelidae and Scarabaeidae in Coleoptera, Vespidae in Hymenoptera, Tipulidae, Syrphidae, Micropezidae and Muscidae in Diptera, two-paired in Orthoptera, Labiduridae in Dermaptera, Plecoptera and Psocoptera, Ichneumonidae in Hymenoptera, and three-paired in Isoptera.

The coxo-basalar muscles are one-paired in many cases, two-paired in some insects such as Mantidae and Phasmidae in Orthoptera.

10. Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles

The muscles connecting the thorax with the trochanters may be divided into five kinds as those in the mesothorax, tergal, pleural and sternal depressors of the trochanters, trochantero-basalar muscles, and pleural levators of the trochanters.

(*a*) *Tergal Depressors of the Trochanters*

The tergal depressors are one-paired in many insects, exceptionally two-paired in Acridiidae of Orthoptera and Syntomidae of Lepidoptera. Odonata, Thysanoptera, Psyllidae in Hemiptera, Coleoptera, Hymenoptera, Tipulidae and Syrphidae in Diptera lack the tergal depressors.

(*b*) *Pleural Depressors of the Trochanters and Trochantero-Basalar Muscles*

The pleural depressors in *Dixippus* (JEZIORSKI, 1918) of Phasmidae in Orthoptera, Labiduridae in Dermaptera, Ephemeroptera, Odonata, Pentatomidae, Corixidae, *Huechys* of Cicadidae and Jassidae in Hemiptera are one-paired, and those in Tipulidae in Diptera are three-paired.

The trochantero-basalar muscles are found in two pairs on Blattidae in Orthoptera, and in a pair on Mantidae, Tettigonidae and

Gryllidae in Orthoptera, Labiidae in Dermaptera, Plecoptera, Isoptera, Embioptera, Psocoptera, Neuroptera, Mecoptera, Trichoptera and Lepidoptera.

Megacrania (MAKI, 1935) of Phasmidae and Acridiidae in Orthoptera, Thysanoptera, Psyllidae in Hemiptera, Coleoptera, Hymenoptera, Stratiomyidae, Syrphidae, Micropezidae and Muscidae in Diptera have neither pleural depressor of the trochanter nor trochantero-basalar muscle.

(*c*) *Sternal Depressors of the Trochanters*

The sternal depressors are found in a pair in general, exceptionally in two pairs on *Macrohomotoma* of Psyllidae in Hemiptera and Stratiomyidae in Diptera, and in three pairs on *Psylla* in Hemiptera, and Dytiscidae (BAUER, 1910) in Coleoptera. Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera and *Nezara* (MALOUF, 1933) of Pentatomidae in Hemiptera lack the sternal depressors. These muscles are divisible into two kinds by their arising positions; ordinary sternal depressors arising on the metafurca, found on many insects, and mesofurcal depressors arising on the mesofurca, found on Jassidae in Hemiptera and Stratiomyidae in Diptera. On the last insect there are also found the ordinary sternal depressors.

(*d*) *Pleural Levators of the Trochanters*

The pleural levators are found in a pair on only Diptera as in those of the mesothorax.

The meso- and metathoracic pleural levators of the trochanters are undoubtedly homologous to the coxal levators of the mesothoracic trochanters in *Ctenacroscelis* of Tipulidae (Fig. 49, 41). The attachments of the pleural levators on the pleura may show that the anterior basal portions of the meso- and metathoracic coxae in higher Diptera and of the metathoracic coxae in lower Diptera have been fused to the pleural regions.

11. Muscles of the Second Thoracic Spiracles

The muscles of the second thoracic spiracles are occlusors. The spiracles may be classified in several types by the number and attached positions of the occlusors.

I. A spiracle provided with an occlusor attached on the lower, anterior or posterior end of the slit-like opening of the spiracle. The spiracles of this types may be subdivided into five kinds by the arising positions of the occlusors:

i. A spiracle provided with an occlusor arising on the subspiraculare. The spiracle of this type is found on Blattidae, Mantidae, Acridiidae and Tettigonidae in Orthoptera, Labiidae in Dermaptera, Isoptera, Thysanoptera, Cicindelidae, Carabidae, Staphylinidae, Coccinellidae, Tenebrionidae and Chrysomelidae in Coleoptera, Stratiomyidae in Diptera.

ii. A spiracle provided with an occlusor arising on the metepisternum. The spiracle of this type is found on Psyllidae in Hemiptera and Ichneumonidae in Hymenoptera.

iii. A spiracle provided with an occlusor arising on the metasternum. The spiracle of this type is found on Labiduridae in Dermaptera, Embioptera and Neuroptera.

iv. A spiracle provided with an occlusor arising on the lateral intersegmental ridge. The spiracle of this type is found on Ecdyonuridae and Ephemeridae (KNOX, 1935) in Ephemeroptera, Odonata, Pentatomidae, Cicadidae and Jassidae in Hemiptera, Mecoptera, Syrphidae, Micropezidae and Muscidae in Diptera.

v. A spiracle provided with an occlusor arising on the posterior margin of the mesepimeron. The spiracle of this type is found on Trichoptera, Lepidoptera, Scarabaeidae in Coleoptera, Tenthredinidae and Vespidae in Hymenoptera, and Tipulidae in Diptera.

II. A spiracle provided with two occlusors.

i. A spiracle provided with two occlusors attached dorsally on the ventral end of the slit-like opening of the spiracle and ventrally on the subspiraculare. The spiracle of this type is found on Phasmidae in Orthoptera and Plecoptera.

ii. A spiracle provided with two occlusors arising on the mesepimeron and inserted into the ventral side of the spiracle. The spiracle of this type is found on Psocoptera.

iii. A spiracle provided with two occlusors, one arising on the

posterior portion of the subspiraculare and inserted into the anterior lip of the spiracle, the other on the ventral portion of the subspiraculare and into the ventral end of the slit-like opening of the spiracle. The spiracle of this type is found on Gryllidae in Orthoptera.

d. Comparison of the Meso- and the Metathoracic Musculature

Comparing the mesothoracic musculature with metathoracic one, the degree of difference between both varies in different insects. In Hemimetabola, the meso- and the metathoracic musculature in Orthoptera, Dermaptera, Plecoptera, Isoptera, Embioptera, etc., especially in Plecoptera, Blattidae in Orthoptera, etc., more resemble each other than in those of the other hemimetabolous insects. In Holometabola, the meso- and the metathoracic musculature in Neuroptera, Mecoptera, Trichoptera, Lepidoptera, etc., are more similar to each other, especially remarkable in the first order, than in those of the other holometabolous insects. The details are here omitted, since those will be readily understood from comparing the tables of pterothoracic muscles shown per order.

e. General Thoracic Musculature in Pterygote Insects

To state the already mentioned results briefly, all the thoracic muscles in pterygote insects can be included into the kinds shown in Table XIX.

As we can understand from the facts already mentioned, although the thoracic musculature varies in different insects, the kinds of muscles shown in Table XX are found on many orders especially lower groups in insects, but the remaining kinds are very special ones found on very limited groups especially higher ones in insects, probably derived from any other muscles. The general thoracic musculature, although its details are undeterminable, may be hypothesized to consist of such kinds as are shown in table XX.

TABLE XIX

a) Prothoracic Muscles

	The number of muscles.																
	Orthoptera	Dermaptera	Plecoptera	Isoptera	Embioptera	Psocoptera	Ephemeroptera	Odonata	Thysanoptera	Hemiptera	Neuroptera	Mecoptera	Trichoptera	Lepidoptera	Coleoptera	Hymenoptera	Diptera
Dorsal Muscles.																	
Median dorsal muscles.	1-2	1	1	1	3	1	1-2	1-2	1	1-2	1	1		1-4	1-3		1
Lateral dorsal muscles.	1-4	1	2	2	1		1	0-1	1	0-2	5		3	1-3	1-2	0-3	0-2
Anterior dorsal muscles.	1-3	1	1	1	1	1	0-1	1	1	0-3	2		1	1-4	0-3		
Ventral Muscles.																	
Long longitudinal or internal ventral muscles.	1-2	1	1	1	1	1	1	0-1		1-3	1	1	1	1	1-2	1-2	1-3
Short longitudinal or external ventral muscles.																	
Ordinary or lateral external ventral muscles.	0-2	1	1		1		0-1	0-2	1	0-1	1	1	1	1-2	0-2	0-2	1
Median external ventral muscles.														0-1			0-1
Cruciate ventral muscles.	0-1																
Anterior ventral muscles.	0-1	1						0-1									
Ventral Transverse Muscles.	0-1	1		1	2	1		0-1			1	1	1	1		0-1	1
Tergo-Sternal Muscles.																	
Anterior intersegmental tergo-sternal muscles.	1-4	1-2	2	2	2	1	1	2	2	0-2	4	2	2	2-3	1-2	1-3	1-4
Anterior internal tergo-sternal muscles.	2-3	1	2	1	1	2	2-5	1	2	0-4	3	2	4	1-2	1-3	0-2	0-2
Anterior external tergo-sternal muscles.	0-2	1			3						2						0-2
Posterior tergo-sternal muscles.	1-2	1	1	2	2	1	1		1	1-2	1	1	1	1	1		0-1

Tergo-Pleural Muscles.																	
Anterior tergo-pleural muscles.	0-3			1		1	1	0-1		0-1			1		0-1	0-1	
Ordinary tergo-pleural muscles.	0-2	1-2	2	1	1	1	0-1	1		0-1	6	3	2	0-3	0-1	0-3	0-1
Sterno-Pleural Muscles.																	
Anterior sterno-pleural muscles.		1															
Furco-entopleural muscles.	0-1		1			1		0-1	1	0-1						0-1	
Coxal Muscles.																	
Tergal promotors of the coxa.	1-4	1	2	1	2	1	1	1-2	4	0-2					0-3		
Pleural promotors of the coxa.	0-1														0-1		0-1
Sternal promotors of the coxa.																	
Ordinary sternal promotors of ths coxa.	0-1	1	2	1	1			0-1	1	0-1	1	1	2	1-2		1	1-2
Anterior sternal promotors of the coxa.	0-1					1		0-1		0-1	1	1		1		0-1	1-2
Tergal remotors of the coxa.	3-6	2	3	3	2	1	3	1-2	1	0-4	1	2	1	0-1	1-3	1	
Pleural remotors of the coxa.											1		1	1-2	0-1	0-1	0-1
Sternal remotors of the coxa.																	
Ordinary sternal remotors of the coxa.	0-1		1	1	1	1	1-3	1		0-2	1	2	1	0-1	0-1	1-2	1-2
Posterior spinal remotors of the coxa.	0-2			1					1				1	0-1		0-1	
Pleural adductors of the coxa.	0-1	1															
Sternal adductors of the coxa.	1		1		1												
Tergal abductors of the coxa.	0-2	1	1	1	1		1-2		3	0-2							
Pleural abductors of the coxa.	1-2	1		1	1	1	1		1	0-2	1	1	2	1-2	0-1	1-2	1-2
Trochanteral Muscles Arising on the Thorax.																	
Tergal depressors of the trochanter.	0-3	1	1	1	1	1		0-1		0-1					0-1		0-1
Pleural depressors of the trochanter.	1-4	1		1	1		1	1	1	0-2		2	1	1	0-3	0-1	0-2
Sternal depressors of the trochanter.	0-1	1	1					1	1	0-1	1	1				0-1	1

TABLE XX.

Hypothetical general thoracic musculature in pterygote insects.

(a) Prothoracic Musculature.

Dorsal Muscles.
- Median dorsals.
- Lateral dorsals.
- Anterior dorsals.

Ventral Muscles.
- Long longitudinal ventrals.
- Short longitudinal ventrals.
- Anterior ventrals.

Ventral Transverse Muscles.

Tergo-Sternal Muscles.
- Anterior intersegmental tergo-sternals.
- Anterior internal tergo-sternals.
- Anterior external tergo-sternals.
- Posterior tergo-sternals.

Tergo-Pleural Muscles.
- Anterior tergo-pleurals.
- Ordinary tergo-pleurals.

Sterno-Pleural Muscles.
- Anterior sterno-pleurals.
- Furco-entopleurals.

Coxal Muscles.
- Tergal promotors.
- Pleural promotors.
- Ordinary sternal promotors.
- Anterior sternal promotors.
- Tergal remotors.
- Pleural remotors.
- Ordinary sternal remotors.
- Posterior spinal remotors.
- Pleural adductors.

Sternal adductors.
Tergal abductors.
Pleural abductors.
Trochanteral Muscles.
Tergal depressors.
Pleural depressors.
Sternal depressors.

(b) Pterothoracic Musculature

Dorsal Muscles.
Median dorsals.
Lateral dorsals.
Dorsal Transverse Muscles.
Ventral Muscles.
Longitudinal ventrals.
Ventral Transverse Muscles.
Anteriors.
Posteriors.
Tergo-Sternal Muscles.
Anteriors.
Posteriors.
Tergo-Pleural Muscles.
Ordinary tergo-pleurals.
Pleuro-axillary muscles.
Pleuro-subalar muscles.
Sterno-Pleural Muscles.
Ordinary sterno-pleurals.
Sterno-basalars.
Furco-entopleurals.
Pleural Muscles.
Coxal Muscles, and Coxal and Trochantinal Wing Muscles.
Tergal promotors of the coxa.
Pleural promotors of the coxa.
Trochantino-basalar muscles.

Ordinary sternal promotors of the coxa.
Anterior spinal promotors of the Coxa.
Tergal remotors of the coxa.
Coxo-subalar muscles.
Ordinary sternal remotors of the coxa.
Posterior spinal remotors of the coxa.
Pleural adductors of the coxa.
Sternal adductors of the coxa.
Tergal abductors of the coxa.
Pleural abductors of the coxa.
Coxo-basalar muscles.

Trochanteral Muscles Arising on the Thorax, and Trochanteral Wing Muscles.

Tergal depressors of the trochanter.
Pleural depressors of the trochanter.
Trochantero-basalar muscles.
Sternal depressors of the trochanter.

Muscles of the spiracle.

Occlusors.

V. MORPHOLOGY OF SOME SKELETAL STRUCTURES

i. Tentorial Bar

The tentorial bar or body in insects is a transverse bridge between tentorial arms of both sides of the head. The tentorial bar in apterygote insects is tendinous, that in pterygote insects is almost chitinized. Concerning the formation of the tentorial bar, it is noteworthy that the bar is usually situated on the upper side of the ventral nerve cord. The representative of muscles crossing over the ventral nerve cord in the other body segments is only the ventral transverse muscles, of which there are two types, one arising on the ventro-lateral portions of the intersegmental region and attached on the ventral median portion of the intersegmental region between the

connectives of the ventral nerve cord, and the other directly stretched between the ventro-lateral portions of the intersegmental region. The first type is found on the thoracic and abdominal segments in apterygote insects, and on the thoracic segments in pterygote insects. The second type is found on the abdominal segments in some apterygote insects, the thoracic segments in some pterygote insects, the abdominal segments in many pterygote insects, the body segments in many chilopods, etc. The ventral transverse muscles in apterygote insects are often transformed into tendinous bars to which the attached positions of ventral muscles and several vertical muscles migrate, the feature of these is similar to that in the tentorial bar of apterygote insects; while those of the mesothorax in some Odonata (*Ceriagrion* of Coenagrionidae, *Deplacodes* of Libellulidae, etc.) are displaced by a hard chitinous bar crossing over the ventral nerve cord, very similar to the tentorial bar in pterygote insects. The tentorial bar seems to be tendinized or chitinized form of ventral transverse muscles in head segments.

ii. Antero-Lateral Portion of the Thoracic Sternum

The boundary between the pleural and the sternal region of each segment in insects is often indistinguishable, because both regions are often fused to each other. Some authors regard that all the ventro-lateral regions of thoracic segments in insects are occupied by the pleural regions, and that, in higher insects, the sternal region is very narrow. It is of no matter that the posterior sternal region between the coxae of both sides in higher insects is narrow, but it is doubtful that the regions near the anterior end of the sternum in higher insects is so narrow as some authors claim.

In the leg-bearing segment of chilopods the longitudinal ventral muscles are attached anteriorly to the antero-lateral elogations of the ventral plate, and posteriorly to the same portions of the following segment. The ventral ends of some tergo-sternal muscles and the lateral ends of the ventral transverse muscles are also attached to

the antero-lateral elongations of the ventral plate. These muscle attachments show that the antero-lateral portions of the ventral plate undoubtedly belong to the sternal region.

In the meso- and metathoracic segments of many apterygote insects, the features of the attachments of the ventral, ventral transverse and tergo-sternal muscles on the antero-lateral elongations of the ventral plates are very similar to those in the leg-bearing segment of chilopods. The antero-lateral elongations of the ventral plates in apterygote insects also seem to be parts of the sternal regions.

The features of muscle attachments on the antero-lateral regions of the ventral plates in the pterothoracic segments of pterygote insects have been considerably modified, the attachments of the anterior ventral transverse muscles are, however, situated on the ventro-lateral portions of the intersegmental regions, rather on the antero-ventral often anterior sides of the so-called episterna (as in Diptera) than on the ventral plate of the pterothorax.

The ventral transverse muscles in chilopods and apterygote and pterygote insects are bundles of fibers arising on the ventro-lateral portions of the intersegmental region as mentioned above, running over the connectives of the ventral nerve cord, attached to the ventral median apophysis between the connectives of the ventral nerve cord, or on the same ventro-lateral portions in the opposite side directly, these features in the muscles are so special that these muscles are very readily distinguishable from other muscles. The ventral transverse muscles in chilopods and apterygote and pterygote insects are very similar and undoubtedly homologous to one another. Hence the lateral attached portions of the ventral transverse muscles on the intersegmental region in pterygote insects may be considered as parts of the sternal regions.

The above mentioned facts may be said to show that all the lateral regions of the pterothoracic segment are not occupied by only the pleural regions, even if the cases in higher pterygote insects, and that the antero-lateral portions of the pterothoracic sternum extend to both sides of the segment often to the anterior sides of pleural

regions as in the cases of the leg-bearing segments in chilopods and of the meso- and metathorax in apterygote insects.

The pleural regions of prothorax in many pterygote insects as well as those of leg-bearing segments in chilopods and apterygote insects are remarkably less developed than those in wing bearing segments in pterygote insects, in general. While the ventro-lateral cervical sclerites in pterygote insects are considerably similar to the antero-lateral portions of the sternum in the leg-bearing segment of apterygote insects and chilopods in the features of their situations and muscle attachments. Probably the most of ventro-lateral cervical sclerites in pterygote insects correspond to the antero-lateral portions of the leg-bearing segment in apterygote insects and chilopods. Since, even the pterothorax having very largely developed pleura, the anterior sternal region considerably extend to both sides as mentioned above, the anterior sternal region in the prothorax having less developed pleura should have also extended to both sides. In some apterygote insects a spina (not so well sclerotized as that in pterothorax in pterygote insects) which has been considered as the invagination' occuring on the ventral intersegmental region, is found on anterior end of the prothoracic sternum immediately behind the head, while in Poduridae the labial segment entirely takes part in the formation of the adult head, these facts seem to show that the most parts of the cervical region of insects belong to the prothoracic region. As far as the most parts of the cervical region belong to the prothoracic region, the most parts of the so-called ventro-lateral cervical sclerites may be considered as parts of the prothoracic sternal region.

iii. Subalar Sclerites

Many wing-bearing insects have small chitinized plates called "subalar sclerite" on the wing bases. The subalar sclerites as well as wing basal sclerites called "basalar sclerites" have been included into the pleural regions in general, but the former sclerites seem to be originated rather on the tergal region than the pleural regions:

The subalar sclerites in many adult insects are usually situated on the under sides of the posterior portions of the wing bases far from the epimera by broad membranous regions at the anterior sides of the lateral portions of the postnotum, and often continuous to the postnotum. While, as far as the author observed on *Leucophaea surinamensis* L. (Blattidae) (Fig. 51) and *Locusta migratoria manilensis* MEYEN (Acridiidae) (Fig. 50), in the late embryonic stage of the former insect the so-called coxo-subalar muscles are attached on the tergal lateral portions which become to the ventral basal portions of the wings when the wings develope in future, in the early nymphal stage in the latter insect the coxo-subalar muscles are attached on the ventral bases of the young wings, and those in both species never attach on the pleura. At the last ecdysis the ventral bases of the wings except the attached portions of the coxo-subalar muscles are well membranized, in other words the attached portions of the coxo-subalar muscles on the ventral bases of the wings (the lateral portions of the primary tergal region) are isolated as so-called subalar sclerites by the membranization of the other parts of the ventral bases of the wings. Hence the subalar sclerites in these insects should be included into the tergal region, never into the pleural regions, and the coxo-subalar muscles into the coxo-tergal muscles, never into the coxo-pleural muscles. From these facts the subalar sclerites in insects seem to belong to the tergal region.

The coxo-subalar muscles are very similar to the tergal remotors of the coxae in their attached positions, may be probably derived from the tergal remotors.

The basalar sclerites are continuous to the primary episterna in the early nymphal stage, and detached from the latter in the adult stage. Hence these belong to the so-called pleural regoins and are not identical to the subalar sclerites in their origins.

The coxo-basalar muscles, trochantino-basalar muscles and trochantero-basalar muscles are bundles of fibers attached dorsally on the basalar sclerites or the flexible antero-dorsal portions of the episterna as already described; in the early wingless stage these are already

developed, attached on the episternal dorsal portions which do not yet detach from the main episternal regions as basalar sclerites, and very similar to the pleural abductors and promotors of the coxae and the pleural depressors of the trochanters respectively in their attached positions and other features; the former muscles are probably homologous to and, in the early stage, serve as the latter muscles respectively. The relation between both will be also understood from the comparison of the musculature in a wingless Dermaptera, *Anisolabis*, and in a winged one, *Labia* (Table III, Figs. 12, 13).

VI. SUMMARY

I. The thoracic muscles of insects can be included in any of the following kinds: Dorsal muscles, dorsal transverse muscles, ventral muscles, ventral transverse muscles, tergo-sternal muscles, tergo-pleural muscles, sterno-pleural muscles, pleural muscles, spiracular muscles, thoracic leg muscles, intrinsic leg muscles, muscles of palsating membranes, thoracic intestinal muscles, and thoracic genital muscles. The present paper deals anatomically with the thoracic muscles except the last four kinds.

II. Thoracic musculature of apterygote insects.

1) The thoracic muscles can be included in any of the following kinds: Dorsal muscles, dorsal transverse muscles, ventral muscles, ventral transverse muscles, tergo-sternal muscles, tergo-pleural muscles, sterno-pleural muscles; coxal muscles, viz. tergal and sternal promotors, tergal and sternal remotors, tergal and pleural abductors; trochanteral muscles arising on the thorax, viz. tergal, pleural and sternal depressors; spiracular muscles.

2) The musculature in Lepismidae and Machilidae, especially in the former, is more complex than that in Campodeidae, Poduridae and Entomobryidae.

3) A special feature in the musculature of apterygote insects is that very long muscles arising on other segments are often present.

4) The arrangement of dorsal muscles varies in different insects.

The arrangements of dorsal muscles of three thoracic segments in Poduridae are uniform, those in Machilidae, Lepismidae, Campodeidae and Entomobryidae are ununiform, but those of meso- and metathorax in Machilidae are similar to each other.

5) The dorsal transverse muscles are found on the meso- and metathorax of Lepismidae, Poduridae, Entomobryidae, and also on the metathorax of Campodeidae.

6) Although the arrangement of ventral muscles varies in different insects, in each insect the meso- and metathoracic ventrals are similar to each other and both are different from the prothoracic ventrals in their arrangements in general.

7) The ventral transverse muscles are found on all the thoracic segments of Lepismidae, and the meso- and metathorax of Machilidae, Poduridae and Entomobryidae, but lacking in Campodeidae.

8) The tergo-sternal muscles attached ventrally on the intersegmental regions are developed in general.

9) The tergo-pleural muscles are found on all the thoracic segments of Machilidae and Lepismidae, but lacking in Campodeidae, Poduridae and Entomobryidae.

10) The sterno-pleural muscles are found on all the thoracic segments of Lepismidae, and the meso- and metathorax of Machilidae, but lacking in Campodeidae, Poduridae and Entomobryidae.

11) The tergal and sternal promotors, tergal and sternal remotors and tergal abductors of the coxae are found on all the thoracic segments in general, exceptionally Lepismidae lacks the tergal abductors but has the pleural abductors of the coxae on all the thoracic segments.

12) Lepismidae has the tergal, pleural and sternal depressors of the trochanters on all the thoracic segments; Machilidae has the tergal depressors on only the prothorax, the pleural depressors on only the mesothorax, and the sternal depressors on only the metathorax; Campodeidae, Poduridae and Entomobryidae have only the sternal depressors on all the thoracic segments.

13) In Poduridae the labial segment, although it entirely takes

part in the formation of the head, can be distinguished from the other parts of the head.

14) Machilidae, Campodeidae and Poduridae have an invagination homologous to the so-called meso- and metaspina on the anterior end of the prothoracic ventral region immediately behind the head.

III. Thoracic musculature of pterygote insects.

i. The thoracic muscles of pterygote insects can be included in any of the kinds show in Table XIX.

a. Prothoracic muscles.

1) In the arrangement of dorsal muscles there are various types. The most common arrangement includes median, lateral and anterior dorsals. Some Hymenoptera lack the dorsal muscles.

2) The long longitudinal ventral and short or external longitudinal ventral muscles are found in general, also the short anterior ventral muscles on some lower insects. The cruciate ventral muscles are restricted on Acridiidae.

3) The ventral transverse muscles are divisible into two types: one stretched between the furcal arms and the spina of the posterior end of the sternum across the upper side of each half of paired connectives of the ventral nerve cord, and found most commonly, and the other between the furcal arms of both sides across the upper side of the ventral nerve cord, and found on Mecoptera and Tipulidae.

4) In the ventral attached portions of anterior intersegmental tergo-sternal muscles there are three types, one attached on the ventro-lateral cervical sclerites, the other on the main prosternal plate, still an other on the profurcal arms, and the first is most common. The anterior internal tergo-sternal muscles are found on many insects, and divisible into four types, the first arising on the protergum or the dorsal cervical region and inserted into the ventro-lateral cervical sclerites, the second on the protergum or the dorsal cervical region and into the lower portion of the head, the third on the mesotergum and into the ventro-lateral cervical sclerites, the fourth on the mesotergum and into the lower portion of the head, and the first is most common. The anterior external tergo-sternal muscles are

found on some lower insects, also on Diptera. The posterior tergo-sternal muscles are one-paired in general, rarely two-paired, but lacking in some higher insects.

5) The tergo-pleural muscles are found in general, but lacking in Thysanoptera.

6) The anterior sterno-pleural muscles are found on Dermaptera. Many insects have either furco-entopleural muscle or trace (furco-pleural chitinous bridge) of the stretching of the furco-entopleural muscle, some insects have neither furco-entopleural muscle nor furco-pleural chitinous bridge.

7) The tergal promotors of the coxae are one-paired in many insects, two-, three- or four-paired in some insects, but often lacking in holometabolous insects.

8) The pleural promotors of the coxae are found on some lower insects and some Coleoptera, but lacking in many insects.

9) Many insects have either ordinary sternal promotor or anterior one, or both, but Ephemeroptera, some Hemiptera and Coleoptera lack the sternal promotors.

10) The tergal remotors of the coxae are found on many insects, and one-, two-, three-, four- or rarely six-paired, but lacking in Diptera and some Lepidoptera.

11) The pleural remotors of the coxae are often found on holometabolous insects, but lacking in hemimetabolous insects.

12) The sternal remotors of the coxae are found on many insects, but lacking in Dermaptera, some Hemiptera and some Coleoptera.

13) The pleural adductors of the coxae are found on Dermaptera as well as Phasmidae and Gryllotalpidae.

14) The sternal adductors of the coxae are found on lower insects in general.

15) The tergal abductors of the coxae are found on many hemimetabolous insects, but lacking in holometabolous insects.

16) The pleural abductors of the coxae are found in one or two pairs on many insects, but lacking in Plecoptera, Odonata, Corixidae, and some Coleoptera.

17) The tergal depressors of the trochanters are one-, two- or three-paired in many hemimetabolous insects and some holometabolous insects. The pleural depressors of the trochanters are found in one, two or rarely three pairs on many insects, but lacking in Plecoptera, Psocoptera, Neuroptera and some higher holometabolous insects. The sternal depressors of the trochanters are one-paired in general, but often lacking.

b. Pterothoracic muscles.

1) Insects will be divisible into following types by dorsal muscles, the first provided with only the median dorsals, the second with only the lateral dorsals, and the third with the median and lateral dorsals; the last is most common. Diptera and many Odonata lack the metathoracic dorsal muscles.

2) The mesothoracic dorsal transverse muscles are fonnd on only Blattidae, the metathoracic ones on Blattidae, Mantidae, Isoptera and Diptera.

3) The longitudinal ventral muscles are found in general. Although there are some other special kinds of ventral muscles, these are found on very limited insects. The spinal ventral muscles may be bundles of fibers derived from ventral transverse muscles.

4) The anterior ventral transverse muscles are divisible into two types, one stretched between the lateral portion of the anterior sternal region and the spina at the anterior end of the sternum, the other between both sides of the anterior sternal region; those in the mesothorax belong to either first or second type, and those in the metathorax to the first type. The posterior ventral transverse muscles are also divisible into two types, one stretched between the furcal arms and the spina of the posterior end of the sternum, the other between the furcal arms of both sides; those in the mesothorax belong to either first or second type, those in the metathorax to the second. The ventral transverse muscles attached on the spina usually run over each half of paired connectives of the ventral nerve cord, and those between the furcal arms run across the upper side of the ventral nerve cord.

5) By the tergo-sternal muscles pterothorax are divisible into five types; the first provided with the anterior tergo-sternal muscles, the second with the posterior tergo-sternal muscles, the third with the anterior and posterior tergo-sternal muscles, the fourth with the anterior tergo-sternal muscles, sterno-subalar muscles and sterno-axillary muscles, and the fifth lacking the tergo-sternal muscles. The last two are rare, especially the fourth type is found on only Ephemeroptera. The third type is most typical.

6) The ordinary tergo-pleural muscles are divisible into anteriors and posteriors, and both are found on pterothorax in general. The pleuro-axillary muscles are one- or two-paired in many insects, three-paired in the mesothorax of Ichneumonidae, six-, seven- or eight-paired in the mesothorax of Diptera; their origins are taken on either episternum or epimeron or both, their insertions are divisible into five types by their positions, the first restricted in Odonata, and taken into the special axillary plates, the second into the first axillary sclerites, the third into the third axillary sclerites, the fourth into the fourth axillary sclerites, and the fifth found on the metathorax of Diptera and taken into the posterior bases of the halters, and the third is most common. The pleuro-subalar muscles arise on the epimeron in general, but those in some Coleoptera on both the epimeron and episternum.

7) The ordinary sterno-pleural muscles, sterno-basalar muscles and furco-entopleural muscles are found on many winged insects, and the sterno-entopleural muscles are found on only the metathorax of Thysanoptera. The furco-entopleural muscles in Plecoptera and many holometabolous insects are two-paired. The meso- and metathorax of Psocoptera and the metathorax of Labiidae and some Hemiptera have no sterno-pleural muscle.

8) The pleural muscles are found on Dermaptera and some higher insects.

9) The tergal promotors of the coxae are found in one or two pairs on many insects, but are lacking in some higher hemimetabolous insects and many higher holometabolous insects.

10) The pleural promotors of the coxae are found on Mantidae, also on the metathorax of Labiduridae and some Hemiptera. The trocahntino-basalar muscles are found on many Orthoptera, Isoptera and Neuroptera, also on the metathorax of Labiidae. The latter may be muscles derived from the former.

11) The ordinary sternal promotors of the coxae are found on many insects, the anterior spinal promotors of the coxae on some lower insects, and the anterior furcal promotors of the coxae on the metathorax of Psocoptera and Agrionidae. Some insects lack the sternal promotors.

12) The tergal remotors of the coxae are found in one, two or three pairs on many insects, but lacking in Odonata and Hymenoptera and also in the metathorax of Diptera.

13) The coxo-subalar muscles are found on winged insects in general, but lacking in Odonata, Corixidae and many higher Diptera, also in the mesothorax of many higher Coleoptera and higher Hymenoptera and the metathorax of Ephemeroptera. These may be muscles derived from tergal remotors of coxae.

14) The coxo-axillary muscles are restricted on Odonata.

15) The ordinary sternal remotors of the coxae are found in general. The posterior spinal remotors are found on the mesothorax of many Orthoptera. Some insects lack both remotors.

16) The pleural adductors of the coxae are found on only Phasmidae.

17) The sternal adductors of the coxae are mainly found on lower insects.

18) The tergal abductors of the coxae are often found on Coleoptera, also on some other insects.

19) By both the pleural abductors of the coxae and the coxobasalar muscles derived from the former muscles pterothorax are divisible into four types, the first provided with only the pleural abductors, the second with only the coxo-basalar muscles, the third with both, and the fourth lacking both. The third type may be most typical in winged insects.

20) The tergal depressors of the trochanters are found in general, but lacking in some higher insects.

21) The trochantero-basalar muscles may be bundles derived from pleural depressors of the trochanters. Either pleural depressor or trochantero-basalar muscle is found in general, rarely both are present, but some insects have neither first nor second.

22) The sternal depressors of the trochanters are found in general. The sternal depressors in the metathorax in Jassidae and Stratiomyidae are very special muscles arising on the mesofurca.

23) The pleural levators of the trochanters are found on higher Diptera, also on the metathorax in lower Diptera. These are homologous to the mesothoracic coxal levators in lower Diptera. These attachments of the pleural levators on the anterior sides of the pleural ridges may show that the anterior basal portions of the pterothoracic coxae in higher Diptera and of the metathoracic coxae in lower Diptera have been fused to the pleural regions.

24) The thoracic spiracle has one or two occlusors in general, the first thoracic spiracle in Acridiidae, Gryllidae, etc. has an occlusor and a dilator. The arising positions of the occlusors are different in various insects. The occluding apparatus of the first thoracic spiracle in Lepidoptera is very characteristic through this order: the occlusor attaches dorsally on the anterior closing lever of the spiracle and ventrally on the ventral end of the spiracle.

25) The degrees of differences between the meso- and metathoracic musculatures vary in different insects. Those are smaller in lower insects than higher ones in both hemimetabolous and holometabolous insects.

ii. A general form of thoracic musculatures in wing-bearing insects may be hypothetically set up as Table XX.

IV. The tentorial bar crossing over the ventral nerve cord may be probably formed by that the ventral transverse muscles of head segments are displaced by tendinous or chitinous matter.

V. The regions near the anterior ends in thoracic sterna considerably extend to both sides. The most parts of ventro-lateral

cervical sclerites in pterygote insects probably belong to the prothoracic sternum.

VI. The subalar sclerites in winged insects probably belong to the tergal region.

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VIII. ABBREVIATIONS

a	Abdominal segments.
an	Antenna.
ap	Anterior notal wing process.
ba	Basalar sclerites.
bs	Basisternal region.
c	Coxa.
cd	Coxal depressors of trochanters.
cl	Clypeus.
cle	Coxal levators of trochanters.
co	Coronal ridge.
col	Collophore.
cs	Coxo-subalar muscles.
dc	Dorsal cervical sclerites.
dlc	Dorso lateral cervical sclerite.
dm	Dorsal muscles.
dt	Dorsal transverse muscles.
e	Epistomal ridge.
em	Epimeron.
es	Episternum.
f	Furca.
h	Head.
it	Intersegmental tendinous plate.
l	Labium.
lm	Labrum.
m	Maxilla.
ma	Muscles of alimentary canal.
md	Mandible.
mn	Median notal ridge.
mpl	Meropleurite.
mr	Meron.
ms	Mesothorax.
mt	Metathorax.
n	Notaulicis.
od	Odoriferous sac.
p	Prothorax.
pa	Prealar sclerite.
pab	Pleural abductors of coxae.
pb	Proboscis.
pc	Precoxal region.
pf	Postfrontal ridge.
ph	Phragma.
pl	Pleuron.
pn	Postnotum.
pos	Posterior sternal plate of apterygote insects.
pp	Posterior notal wing process.
pr	Pleural ridge and pleural arm.

ps	Presternal region.
psc.	Prescutum.
s	Sternum.
sa	Subalar sclerite.
sad	Sternal adductors of coxae.
sc	Scutum.
scb	Attached positions of sterno-basalar muscles and coxobasalar muscles.
scl	Scutellum.
scx	Subcoxa.
sd	Sternal depressors of trochanters.
sl	Sternellum.
sle	Sternal levators of trochanters.
sn	Spina.
sns	Spinasternum.
sp	Spiracle.
splm	Sterno-pleural muscles.
spm	Spiracular muscles.
spr.	Sternal promotors of coxae.
sr.	Sternal remotors of coxae.
ssp	Subspiracular sclerite.
st	Stylus.
t	Tergum.
ta	Anterior arm of tentorium.
tab	Tergal abductors of coxae.
tb	Tentorial bar.
tctb	Attached positions of trochantino-basalar muscles, coxo-basalar muscles and trochantero-basalar muscles.
td	Dorsal arm of tentorium.
ten	Tentorium.
tg	Tegula.
tn	Trochantin.
tp	Posterior arm of tentorium.
tpl	Tergo-pleural muscles.
tpr.	Tergal promotors of coxae.
tr	Tergal remotors of coxae.
ts	Tergo-sternal muscles.
ty	Tympanal organ.
v	Verruca.
vc	Ventral cervical sclerite.
vlc	Ventro-lateral cervical sclerite.
vm	Ventral muscles.
vs	Retractile vesicle of abdomen.
vt	Ventral transverse muscles.
8th, 9th	The eighth and ninth body segments of an unknown chilopod.

IX. EXPLANATION OF THE PLATES

Plate I

Fig. 1. Thoracic and anterior abdominal musculatures. *Pedetontus* sp.
Fig. 2. " " " " *Lepisma saccharina*
Fig. 3. Musculatures of head, thorax and anterior abdominal segments. *Lepidocampa weberi*

Plate II

Fig. 4. Musculatures of head, thorax and anterior abdominal segments. *Neanura*
Fig. 5. " " *Folsomia sp.*
Fig. 6. Musculatures of thorax and anterior abdominal segments. *Periplaneta australasiae*

Plate III

Fig. 7. Musculatures of thorax and anterior abdominal segments. *Hierodula patellifera*
Fig. 8. " " *Locusta migratoria manilensis*
Fig. 9. " " *Atractomorpha ambigua*

Plate IV

Fig. 10. Musculatures of thorax and anterior abdominal segments. *Xiphidion maculatum*
Fig. 11. " " *Brachytrupes portentosus*
Fig. 12. " " *Anisolabis annulipes*

Plate V

Fig. 13. Musculatures of thorax and anterior abdominal segments. *Labia curvicauda*
Fig. 14. " " *Neoperla formosana*
Fig. 15. " " *Odontotermes formosanus*

Plate VI

Fig. 16. Musculatures of thorax and anterior abdominal segments. *Oligotoma saundersi*
Fig. 17. " " *Psocus tokyoensis*
Fig. 18. " " *Ecdyonurus hyalinus*

Plate VII

Fig. 19. Musculatures of thorax and anterior abdominal segments. *Crocothemis servila*
Fig. 20. " " *Psolodesmus mandarinus*
Fig. 21. " " *Machatothrips artocarpi*

Plate VIII

Fig. 22. Musculatures of thorax and anterior abdominal segments. *Eurostus validus*
Fig. 23. " " *Sigara substriata*
Fig. 24. " " *Huechys sanguinea*

Plate IX

Fig. 25. Musculatures of thorax and anterior abdominal segments. *Cicadella feruginea*
Fig. 26. " " *Macrohomotoma gladiatum*
Fig. 27. " " *Neopanorpa ophthalmica*

Plate X

Fig. 28. Musculatures of thorax and anterior abdominal segments. *Stenopsyche griseipennis*
Fig. 29. „ „ *Plutella maculipennis*
Fig. 30. „ „ *Adoxophyes privatana*

Plate XI

Fig. 31. Musculatures of thorax and anterior abdominal segments. *Papilio thaiwanus*
Fig. 32. „ „ *Milionia zonea*
Fig. 33. „ „ *Amata lucerna*

Plate XII

Fig. 34. Musculatures of thorax and anterior abdominal segments. *Cicindela kaleea*
Fig. 35. „ „ *Chlaenius naeviger*
Fig. 36. „ „ *Borolinus minutus*

Plate XIII

Fig. 37. Musculatures of thorax and anterior abdominal segments. *Epilachna vigintioctopunctata*
Fig. 38. „ „ *Ceropria induta*
Fig. 39. „ „ *Rhaphidopalpa femoralis*

Plate XIV

Fig. 40. Musculatures of thorax and anterior abdominal segments. *Mimela testaceoviridis*
Fig. 41. „ „ *Eutomostethus formosanus*
Fig. 42. „ „ *Philopsyche sauteri*

Plate XV

Fig. 43. Musculatures of thorax and anterior abdominal segments. *Vespa ducalis*
Fig. 44. „ „ *Ctenacroscelis mikado*
Fig. 45. „ „ *Pecticus latifascia*

Plate XVI

Fig. 46. Musculatures of thorax and anterior abdominal segments. *Lathyrophthalmus obscuritarsis*
Fig. 47. „ „ *Calobata sinensis*
Fig. 48. „ „ *Orthellia claripennis*

Plate XVII

Fig. 49. Musculature of the ninth body segment in an unknown chilopod provided with fifteen pairs of legs.
Fig. 50. Showing of attached positions of some vertical muscles of pterothorax in nymphal stage of *Locusta migratoria manilensis.*
Fig. 51. Showing of attached positions of some vertical muscles of pterothorax in late embryonic stage of *Leucophaea surinamensis.*

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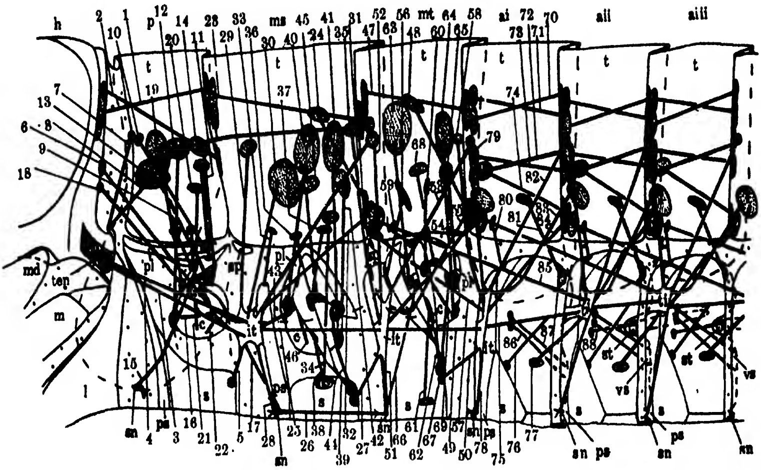

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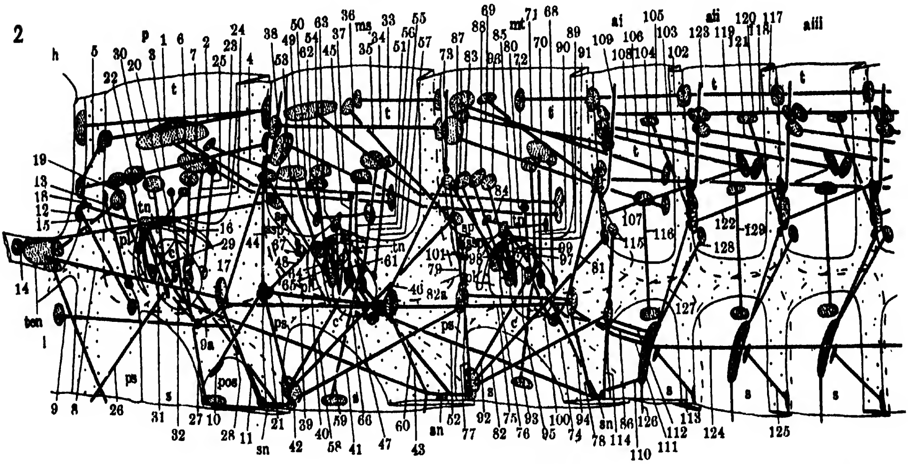

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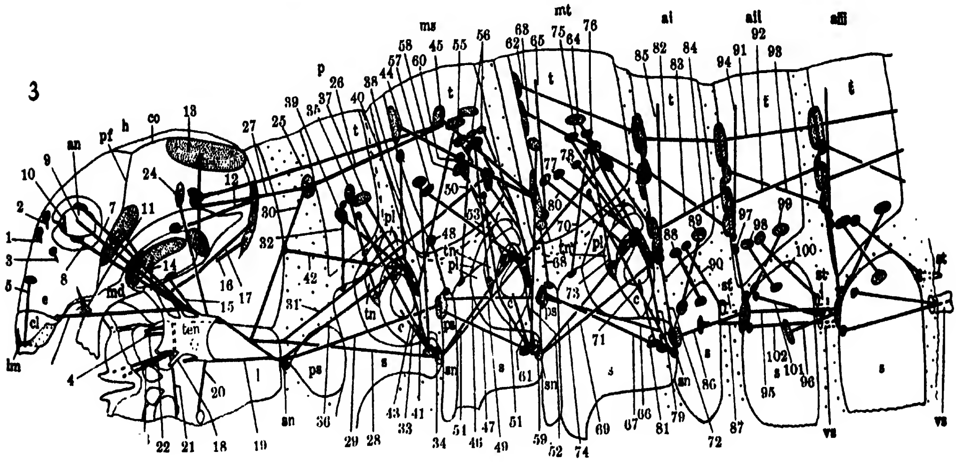

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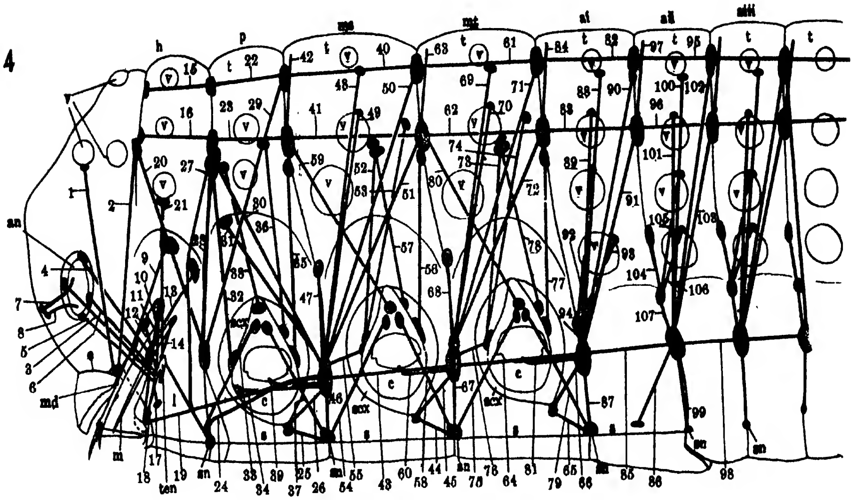

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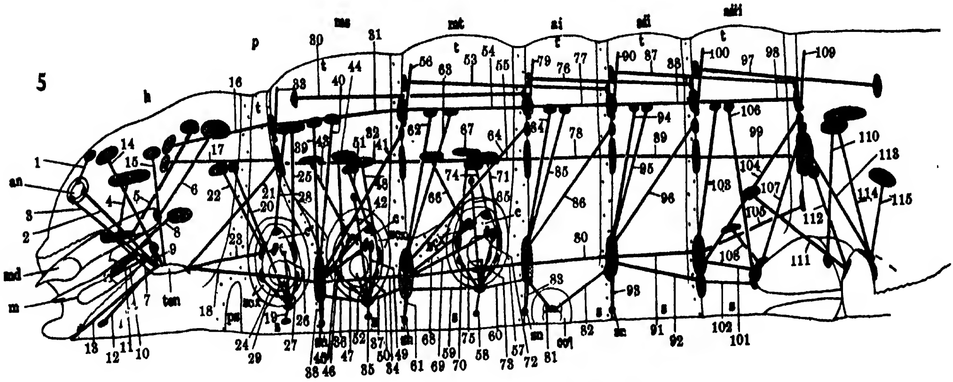

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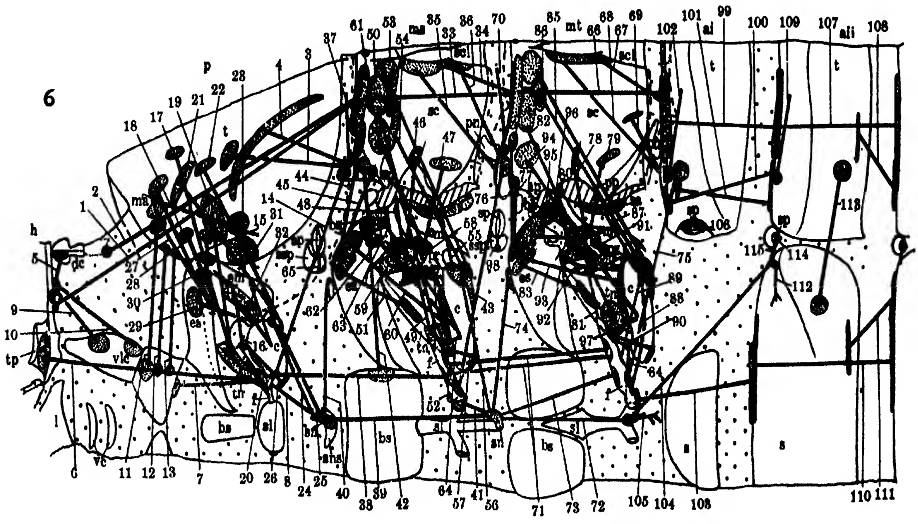

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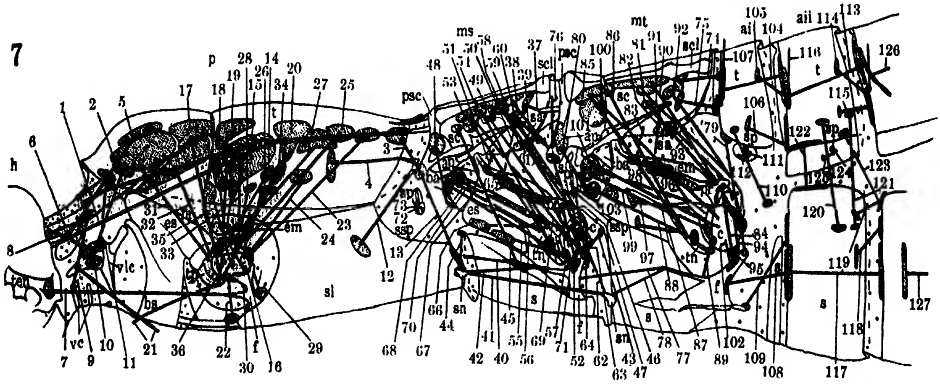

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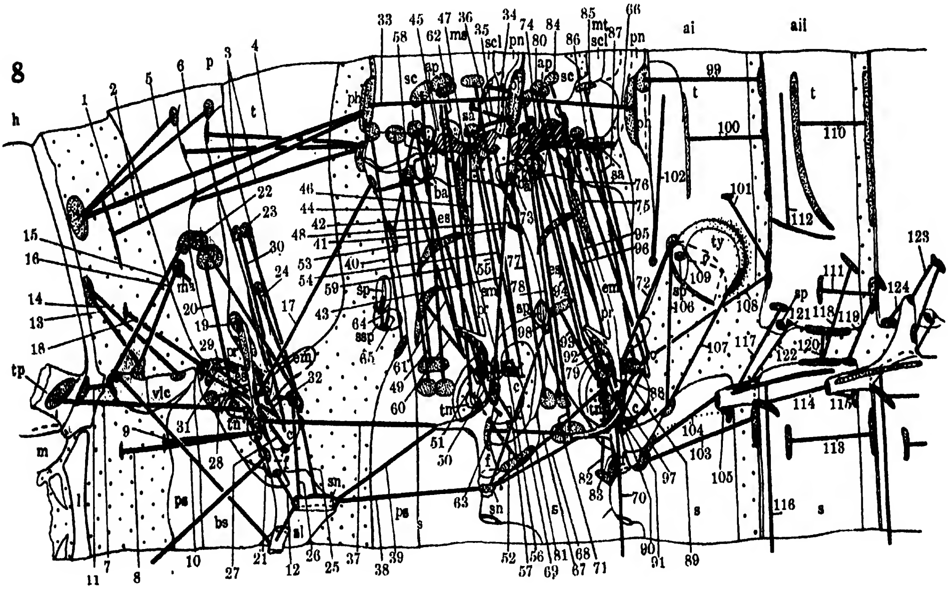

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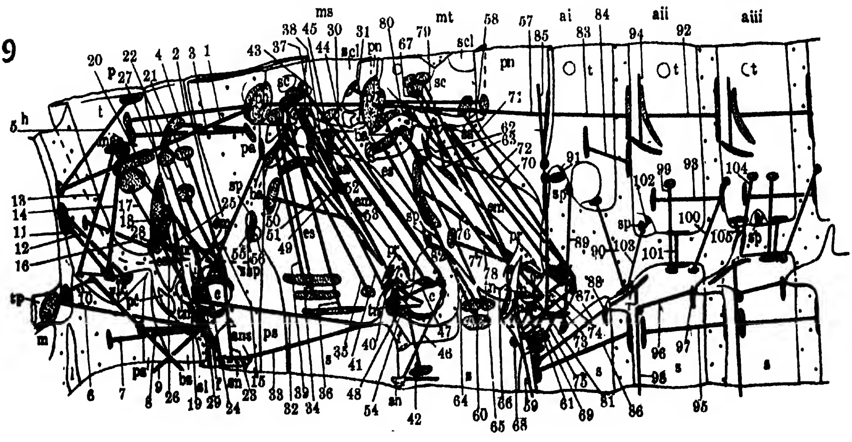

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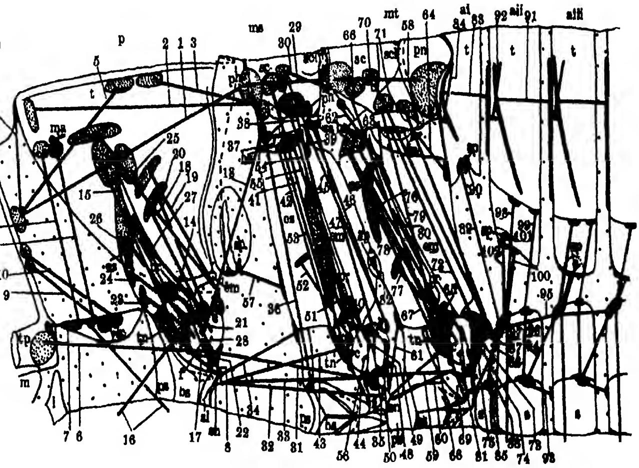

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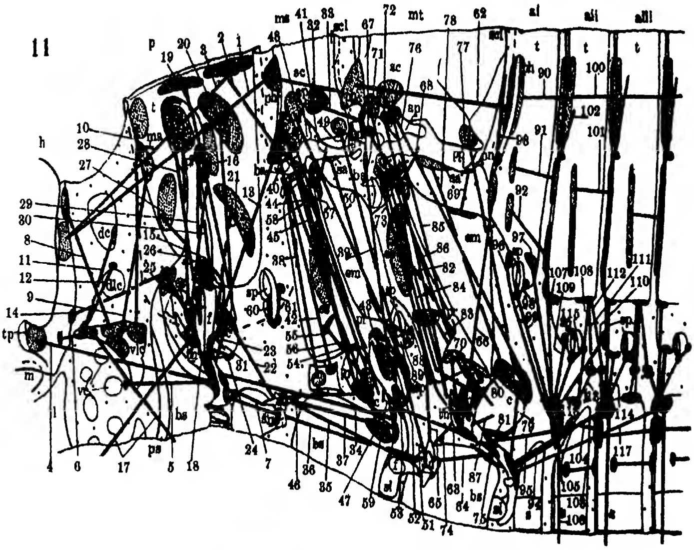

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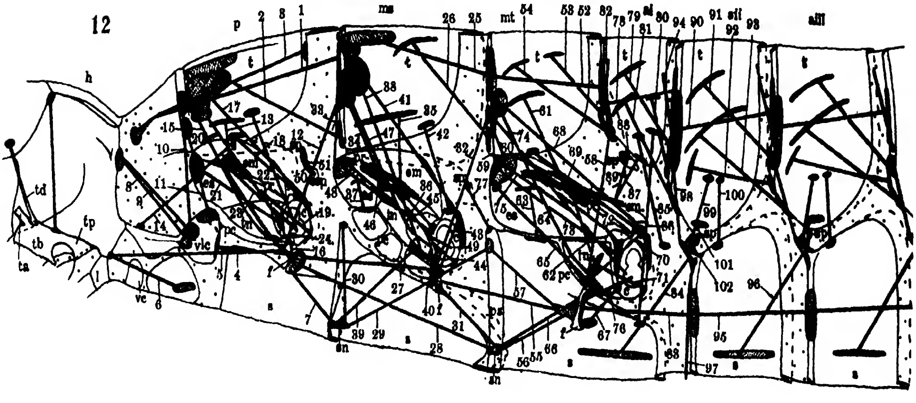

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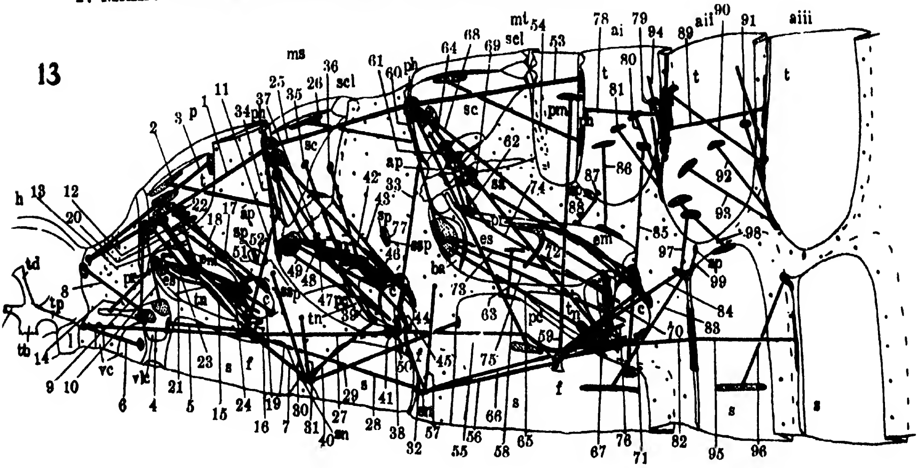

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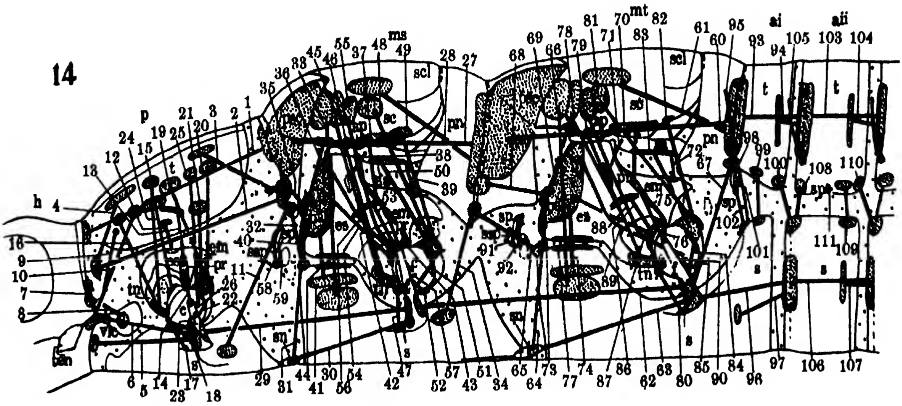

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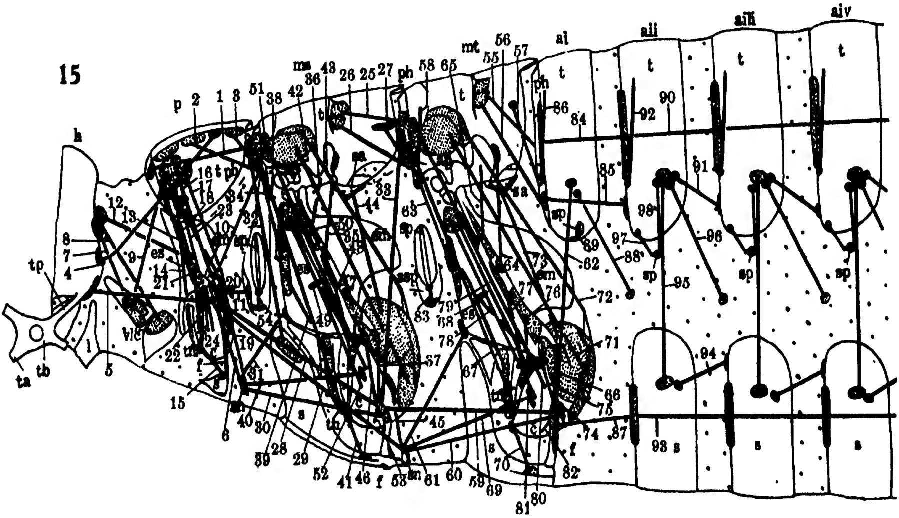

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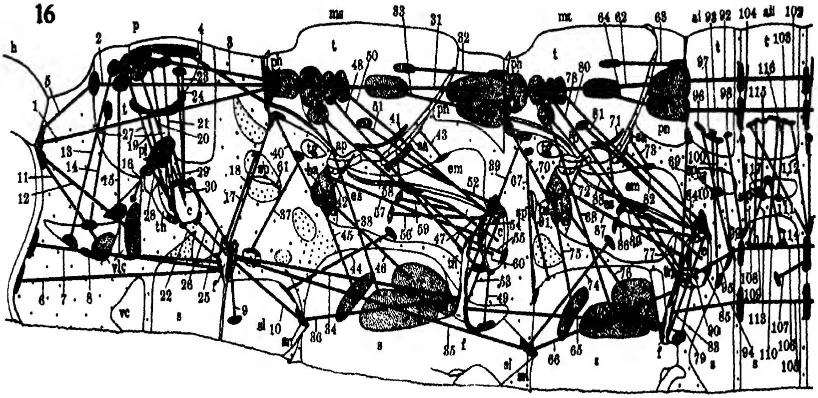

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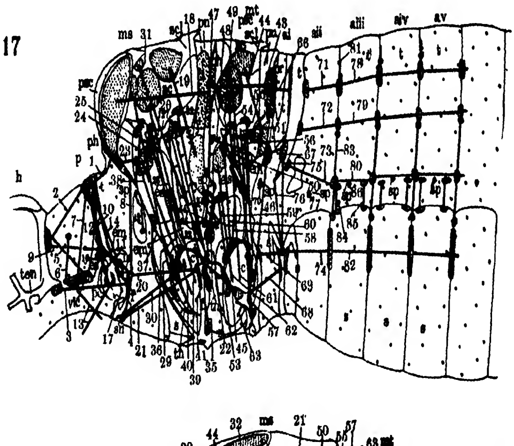

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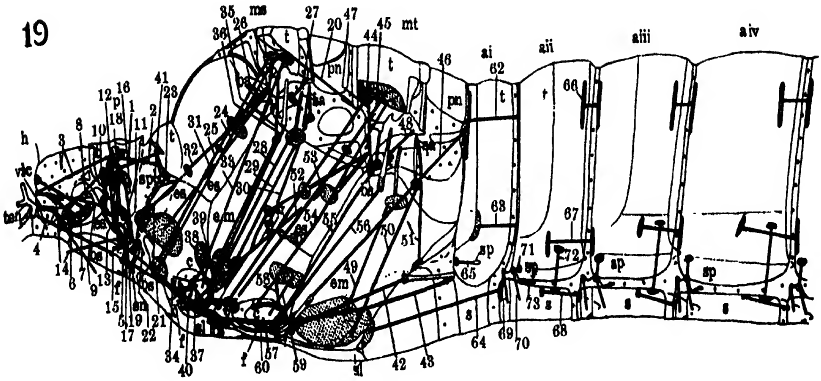

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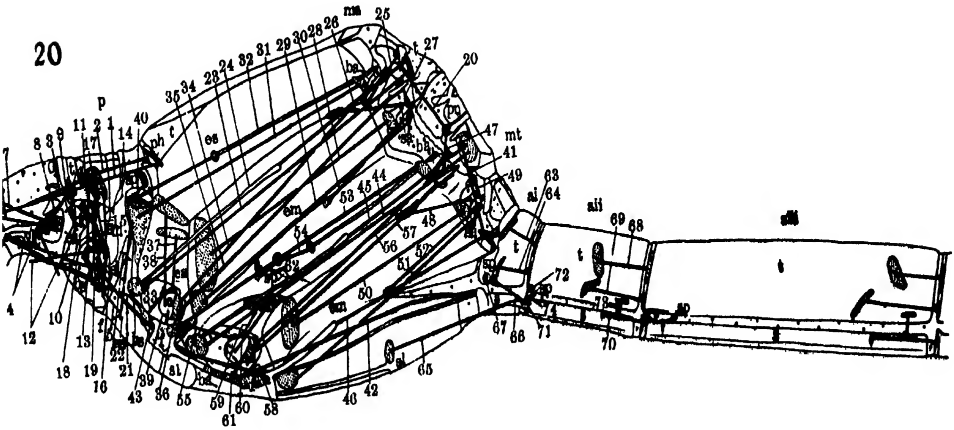

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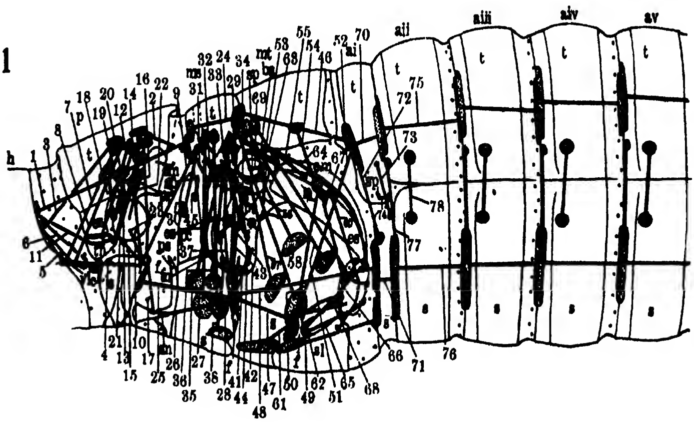

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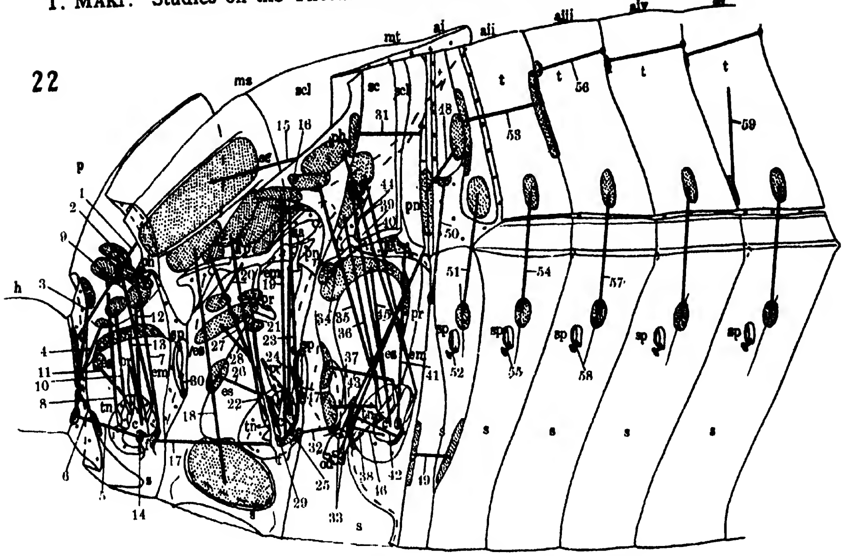
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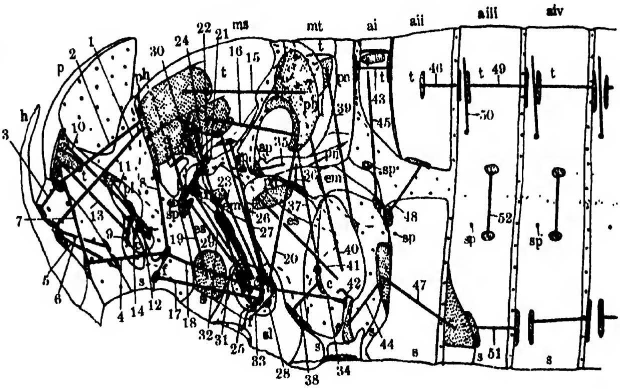
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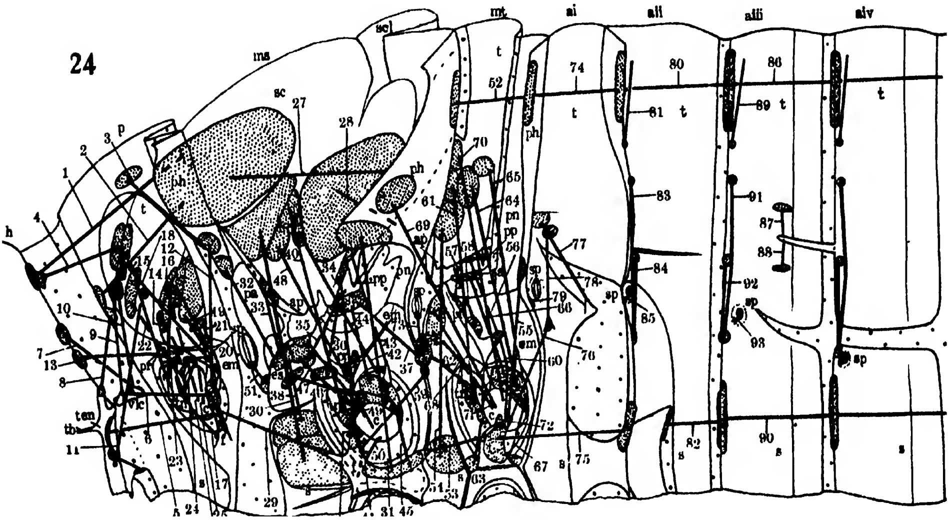
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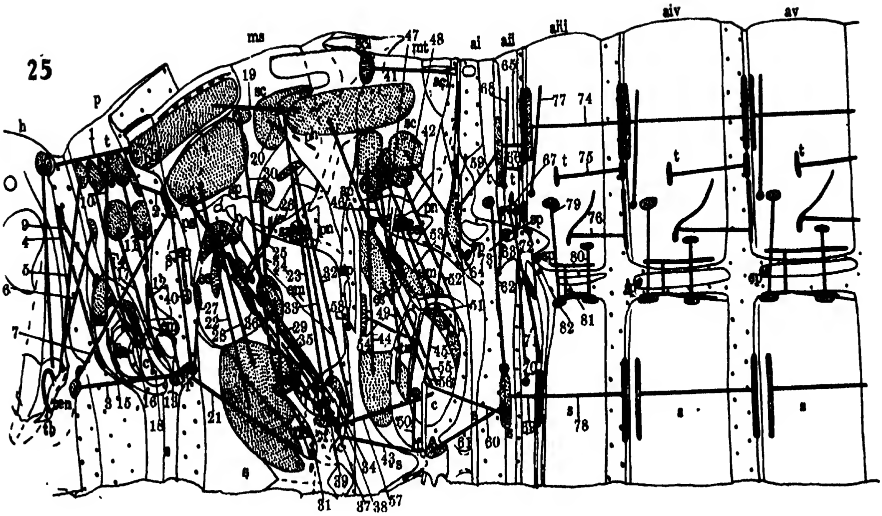

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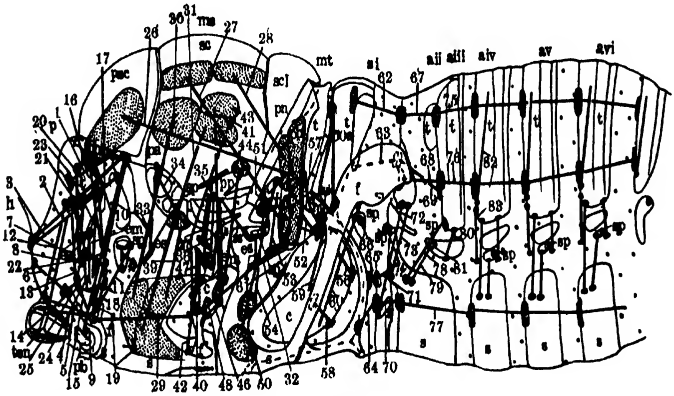

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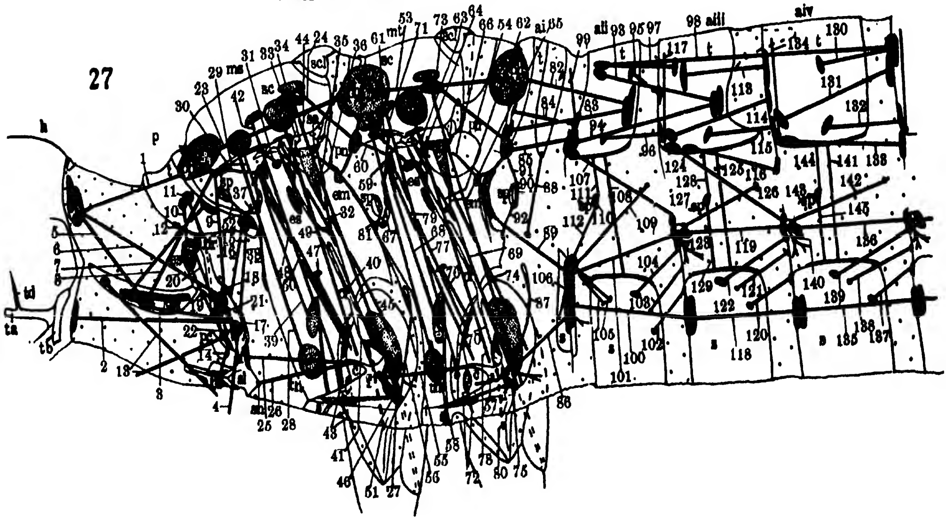

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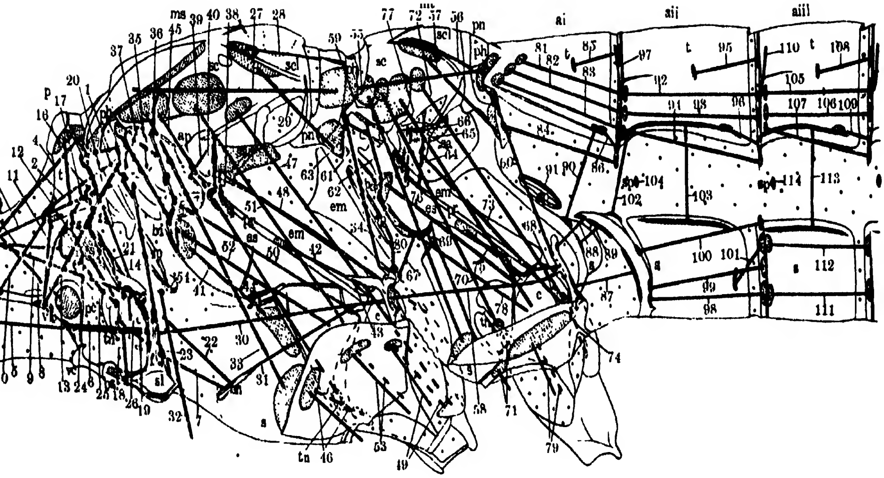

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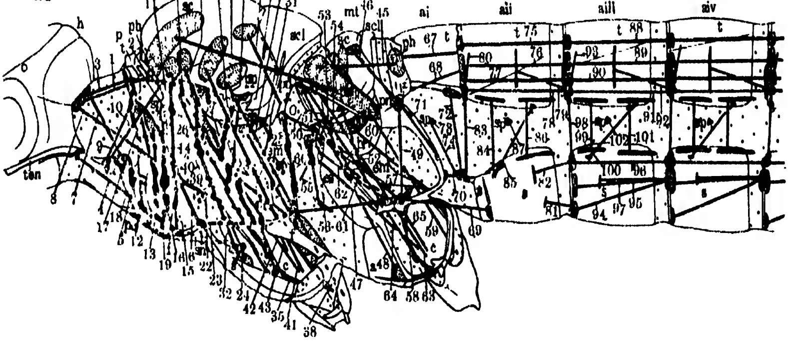

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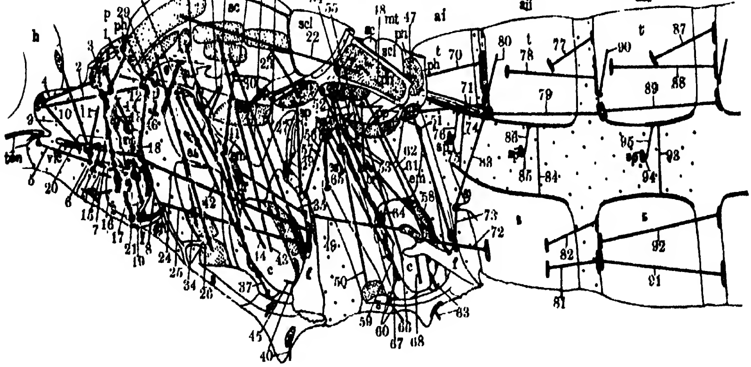

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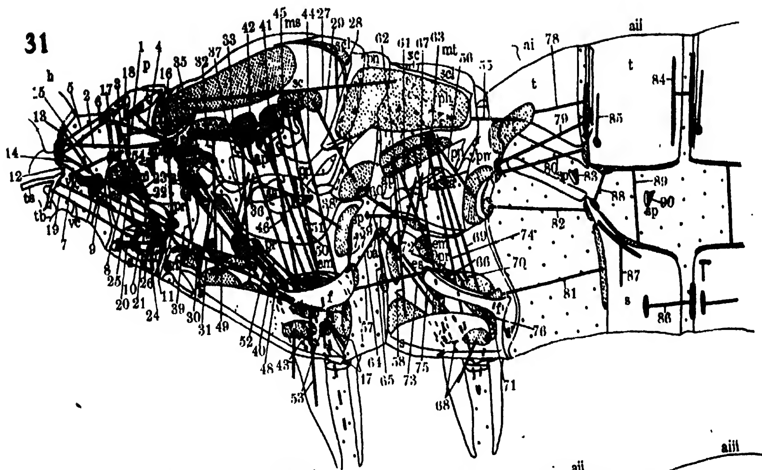

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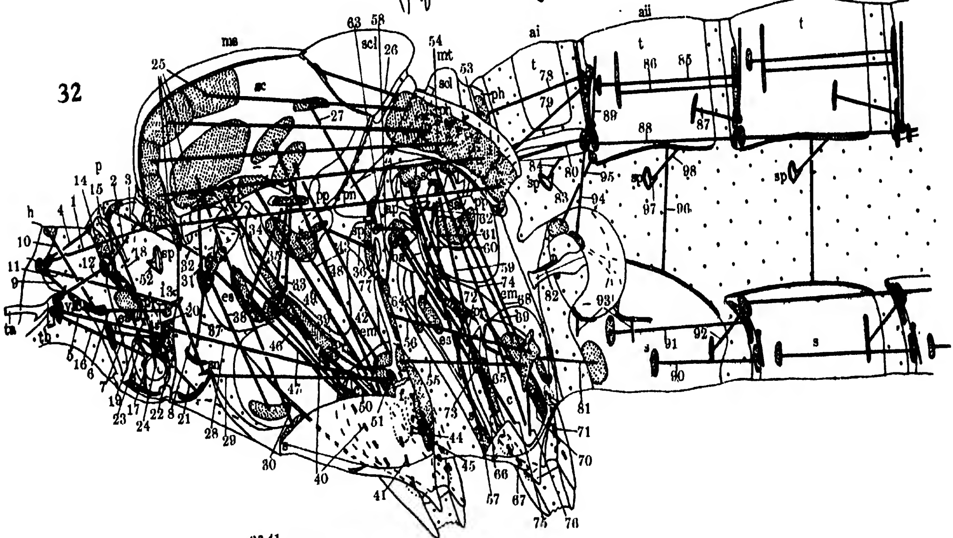

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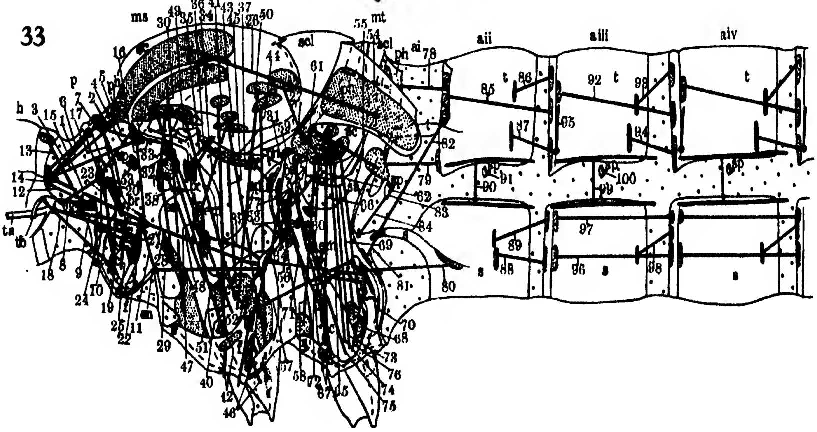

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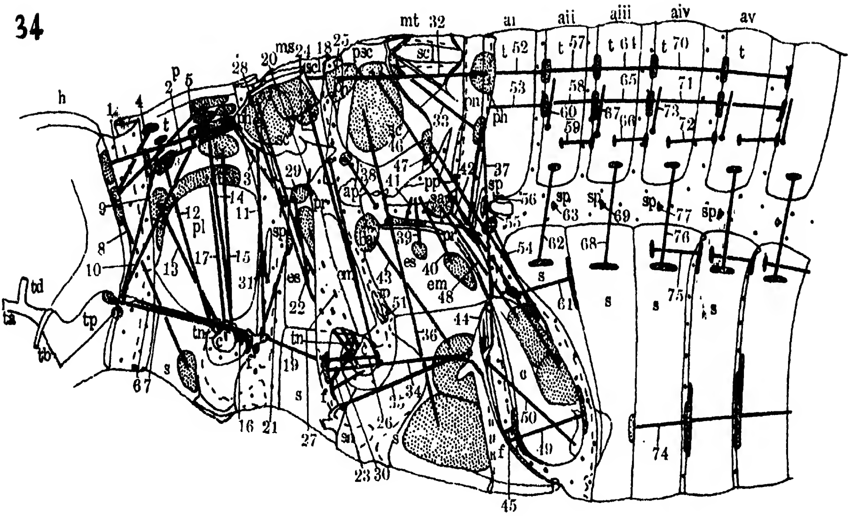
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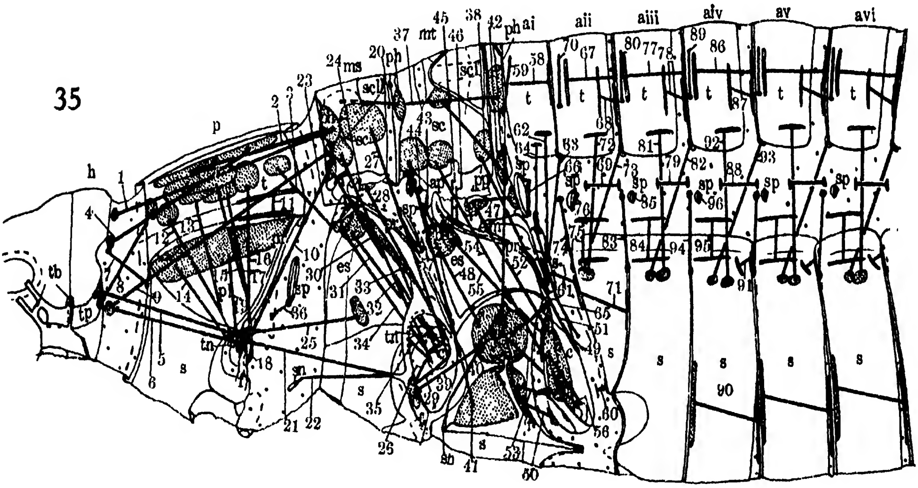
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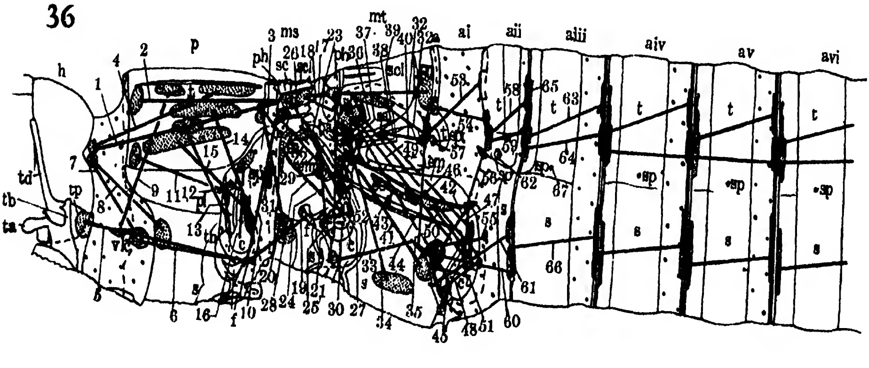
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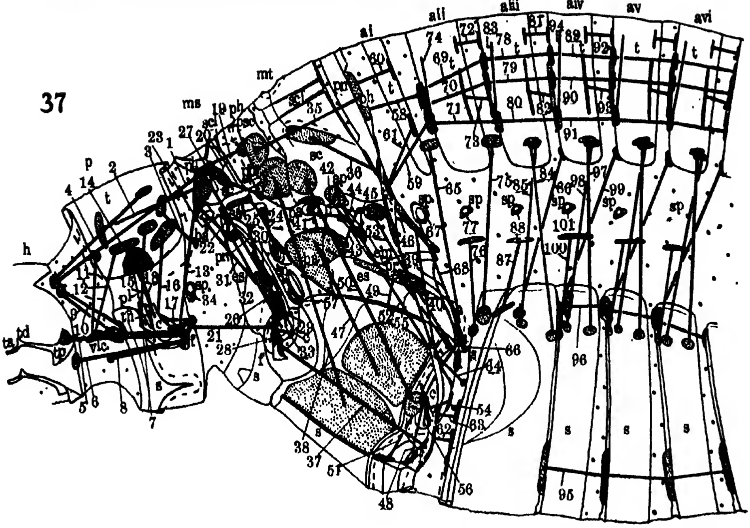

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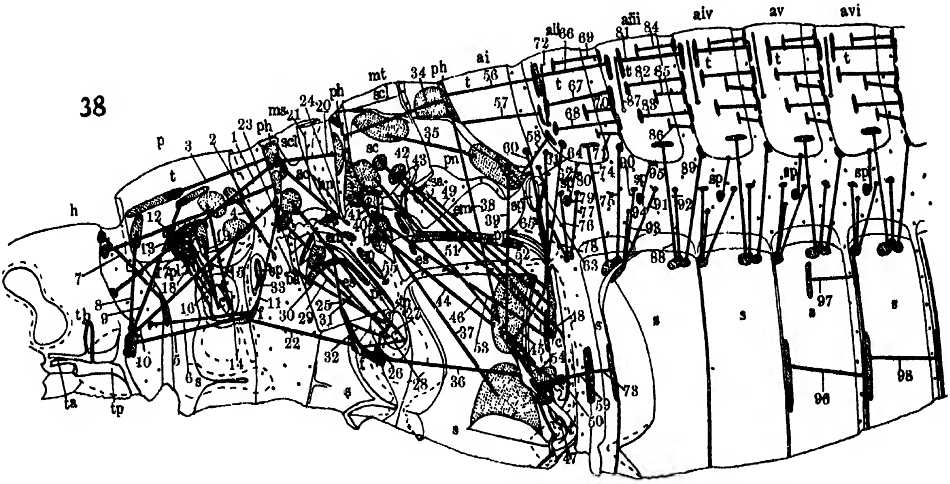

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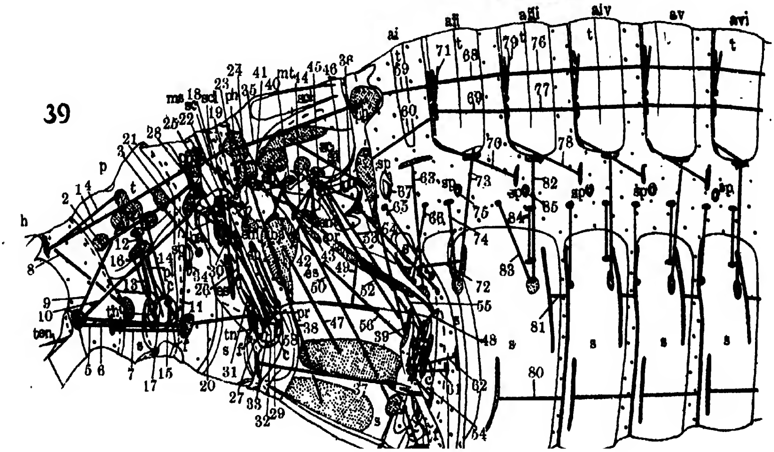

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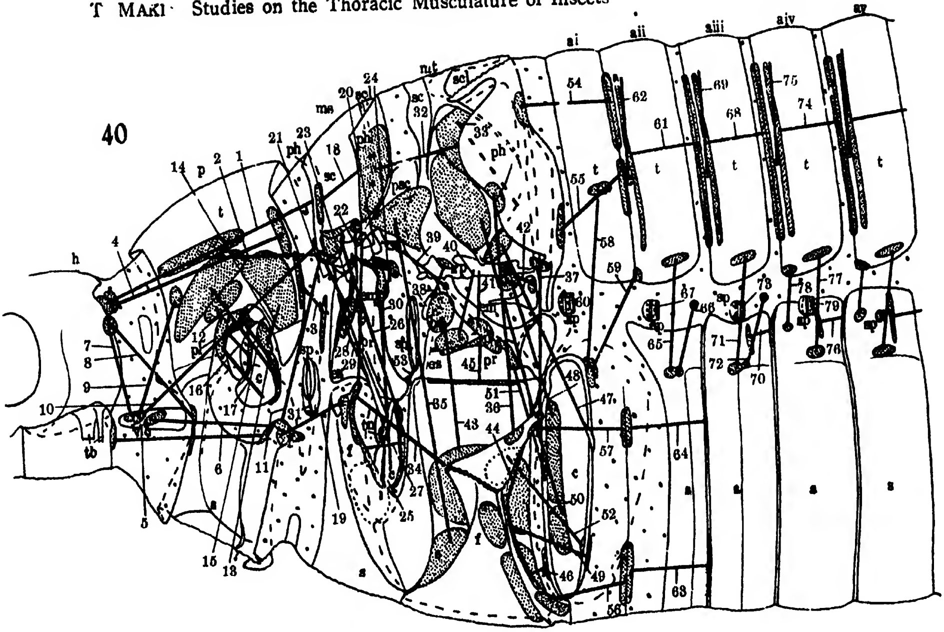

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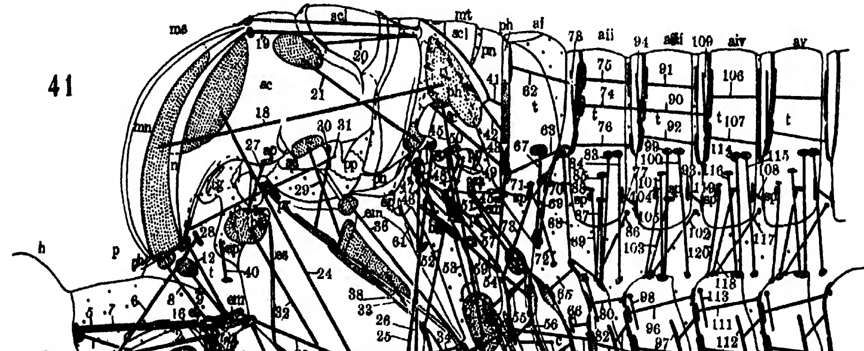

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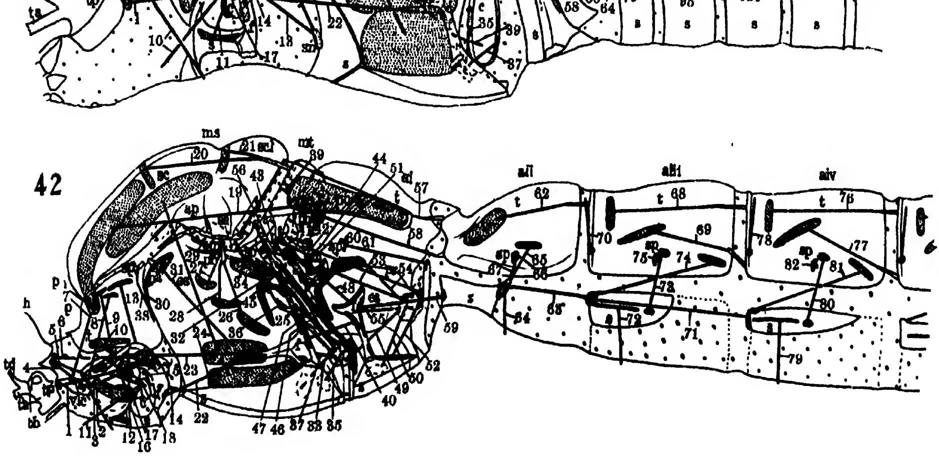

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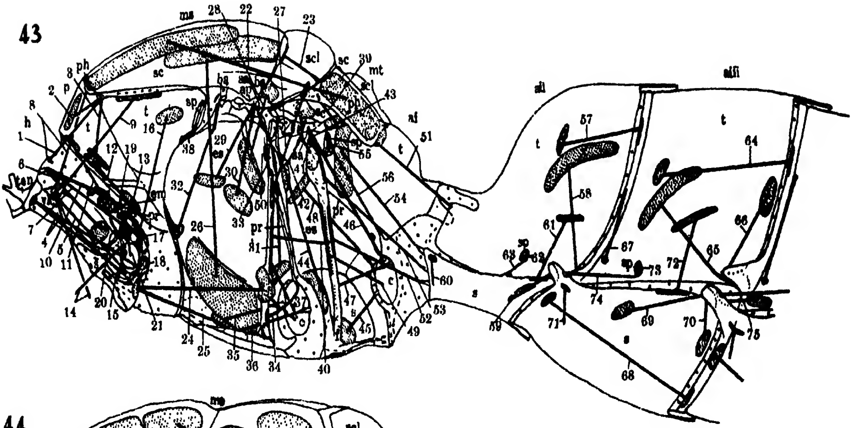

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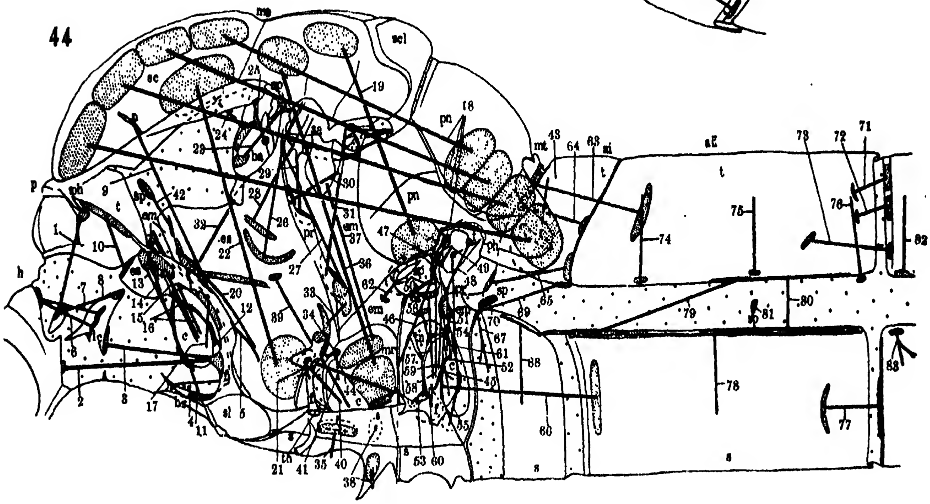

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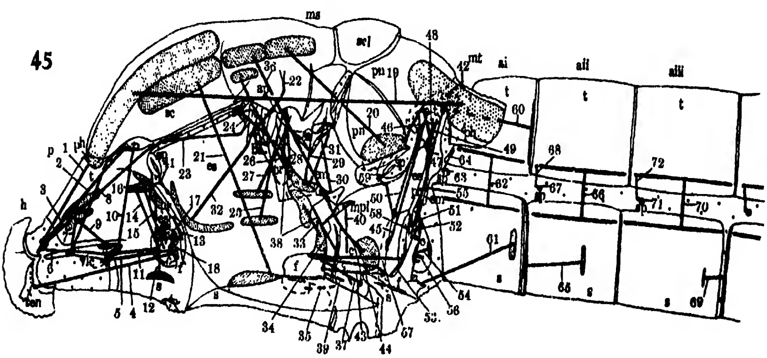

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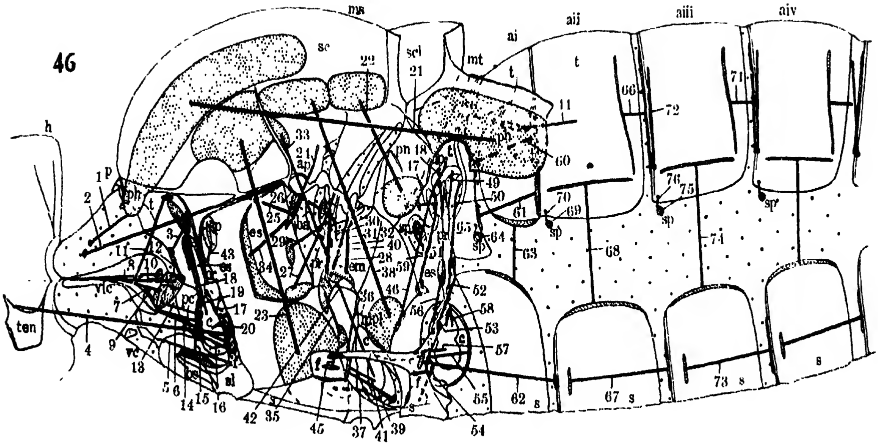
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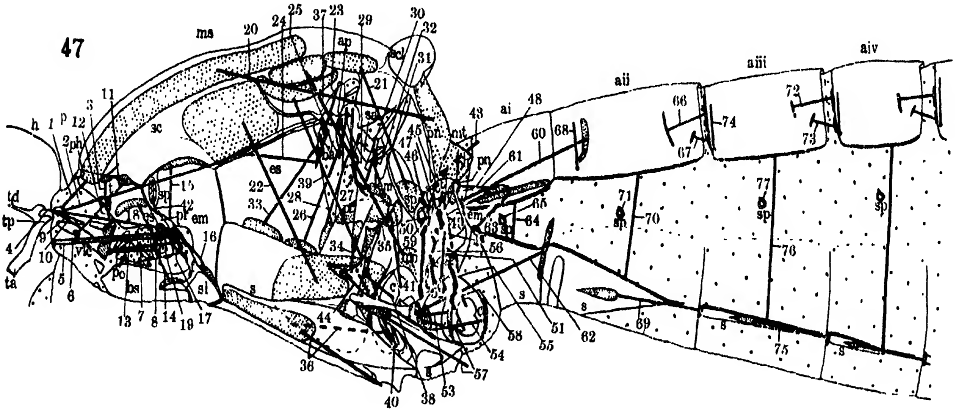
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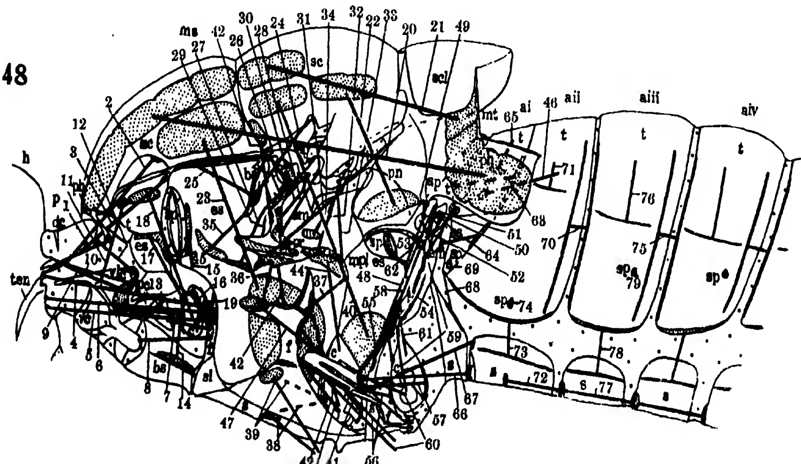
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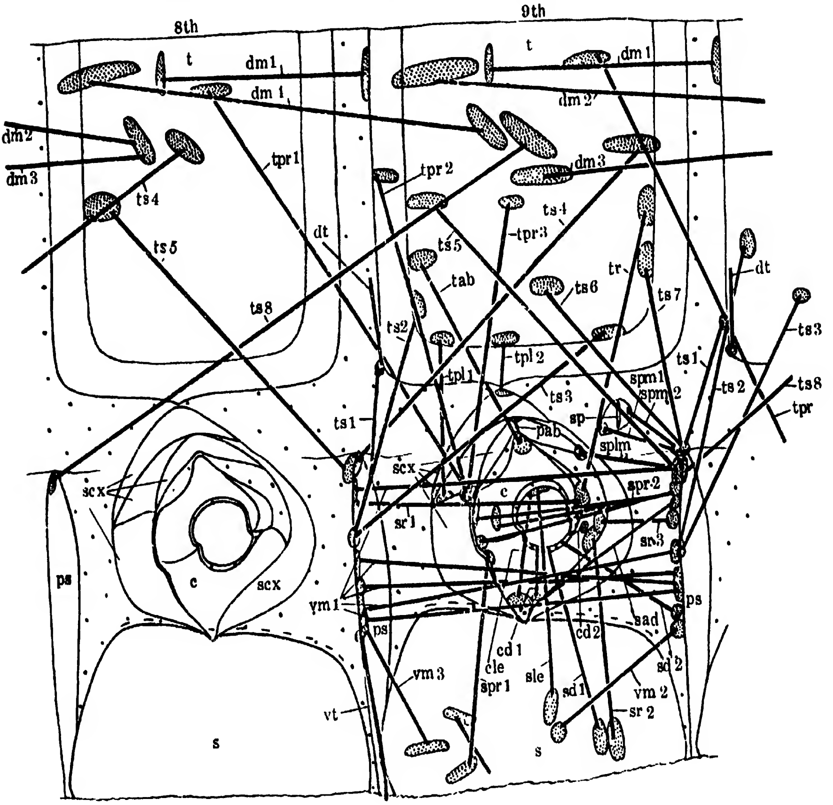
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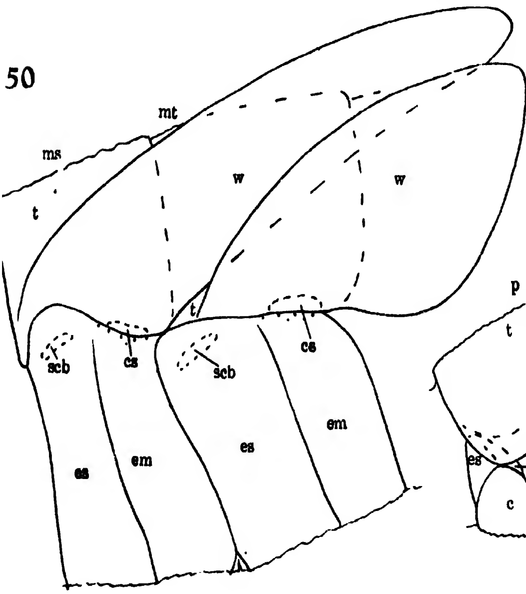
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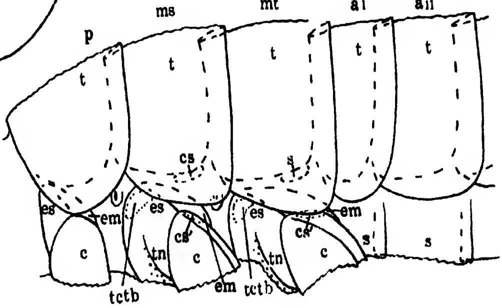
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